NOTICE.

Speaking of Furnaces, there is probably more difference in cellar furnaces (even within corresponding grades) than in any other household essential. That is to say, a cellar furnace which is a really good one, constructed on scientific principles, and costing $400 or $500, may be so complicated that it takes an educated engineer to run it; and it may have so many scientific parts that one or the other of them is almost always worn out or out of order and the furnace "won't work" There is another class that might be called the "practical" or "common-sense" cellar furnace, simple in construction, durable, entirely easy to operate and dead sure to give satisfaction. Of course there are a great many of this latter class made in this country and Canada, and we do not want to make any invidious comparisons about the different makes of furnaces, but we feel compelled to mention right here that the "Radiant" and the "Model" and the "Palace" are probably the best examples of these "practical," "common-sense" cellar furnaces. Take the "Palace" for instance:—A "Palace" furnace will heat a small house with entire satisfaction, (satisfaction to the **user** as well as to the maker and seller) and can be put up for $35 or $40 and leave a profit to the dealer. Well, no householder is going to kick at that price,—hardly!

Then the "Radiant" is a higher grade and more expensive furnace (cast iron crab construction with heavy sheet-steel drums) and a great big sized "Radiant" to thoroughly heat a large house can be put up for about $100 or $150 and leave a mighty handsome profit for the dealer.

Then again the "Model" comes in between the "Palace" and the "Radiant," and is just as good as either in proportion to its capacity and price. This is not the place, however, to go into details, but you can get full information from the Mt. Penn Stove Works, who make these three furnaces at their foundry at Reading, Pennsylvania, and they of course will be glad to give you all particulars about the "Radiant" and the "Model" and the "Palace."

We only started out to try to show that a satisfactory cellar furnace may be bought for little money, and a trial will prove our position.

Jan 31 - 96 - 4 Hours

George M. Clark & Company

Makers of

Jewel Gasolene Stoves

Office and Factory

149 to 161 Superior Street

Chicago

THE

FURNACE WORK MANUAL.

An Exposition of Furnace Work in All its Branches.

COMPILED

FROM FILES OF THE AMERICAN ARTISAN.

—BY—

SIDNEY P. JOHNSTON,

—FOR—

All in Any Way Interested in Practical Furnace Work.

1895.
THE AMERICAN ARTISAN PRESS,
69 Dearborn Street,
CHICAGO.

PREFACE.

The subject of heating by warm air is not a new one by any means, and there is not the least doubt in my mind that the books treating on this subject, wholly or in part, form a very respectable library.

These various works, as far as I have looked into them, appeal to the heating engineer, the architect, or the student of the theory of heat, and not to the practical furnace worker.

The present volume may not commend itself to those looking for any new theories of the combination of gases or the deflection of heat, as it deals with the practical problems arising from furnace work, and with them alone. I have striven, to the best of my ability, to produce a work of practical value on this subject, and to answer any and all questions that might arise in the every day work of furnace men.

I modestly hope that this work may cover its chosen field in a creditable manner, and fill a niche in heating literature that has been more or less neglected in the past.

THE COMPILER.

CHICAGO, ILL., Oct., 1894.

CONTENTS.

I.

INTRODUCTION.

The use of warm or hot air furnaces, both cast iron, wrought iron and steel plate, for heating and ventilating houses and buildings of every description, except in some cases buildings of the largest dimensions, is ever increasing and gaining in popularity. Their use for all sizes of dwellings is in particular, other considerations being equal, the preferable one, in the opinion of the writer. Their comparative cheapness as to first cost, and ready adaptability to most all conditions and requirements met with in almost any case, compared with other systems of heating, as steam or hot water; this being a most potent factor in some cases, I may say, is the main inducement to buy to many purchasers and users of a heating apparatus. They perhaps otherwise would never have put in a heating apparatus at all, but would have contented themselves with the, at the present day, antiquated and wasteful use of stoves as compared with a system of heating by hot-air furnaces.

Then again, furnaces of all kinds are the most readily sold and handled by the majority of general hardware and tinware dealers throughout the country. Their facilities for doing this kind of work not being adapted for the proper putting in and erecting of steam and hot water systems, but for the setting of furnaces, the most dealers have every appliance needed, such as tools in their tinshop, and also their mechanics, as tinners and sheet-iron workers. I also may add that even the largest furnace houses, who also handle hot water and steam heaters, in as large a city as Chicago, have found it too costly to maintain a separate shop or plant for setting up and putting in hot water and steam systems, but merely content themselves with selling the apparatus and then letting the work of putting in the plant to outsiders, such as plumbers, steam and hot water fitters.

The foregoing is sufficient to show some few reasons why the hot air furnace business and trade is so overwhelmingly larger than that of any other system employed for the end sought, at the present time, and always will be. I will not at the present time discuss the good or poor points of any of the other systems, but will endeavor to give a full exposition of the best practice that has come to the notice of the writer as employed by the leading shops of the country for getting out furnace work and the proper setting of same. There has not as yet ever come to my notice a clear and logical written or printed statement of connected ideas on this subject, which would prove of much practical value to the ordinary, every-day practical furnace man, that would stand the searching crucible test of proof.

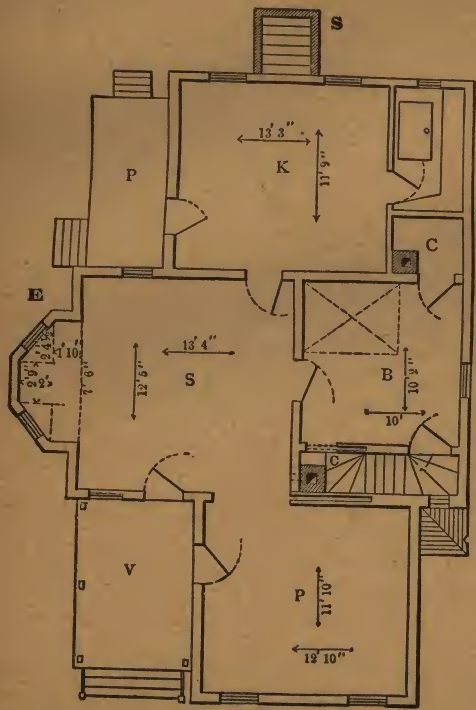
Realizing this want I will endeavor to give, in a systematic manner, the entire *modus operandi* which is necessary for the manufacture, location and proper putting up of different kinds of both cast iron and steel or wrought plate furnaces. In this series of articles I will give all patterns required for this work, also complete and comprehensive data and tables as necessary for the proper and correct calculations which come up in actual work and practice almost every day.

All calculations will be in plain figures so as to be readily understood by the most ordinary mind. It will be seen as we go along that I will make free and frequent use of practical and experimental data from the works of the most eminent engineers on this subject, such as Box, Dalton, Hood, Galton, Schuemann and others; although it is sometimes claimed that their conclusions as compared with each other often vary, and seemingly on the surface they do so. But then this is often due to the peculiar conditions and circumstances under which their tests and experiments were made. Whenever necessary these discrepancies will be explained. Whenever it is expedient sketches and drawings will be used to show a point clearly. As to my opinion in many cases no amount of written description could so graphically and clearly show and explain an object as a simple sketch. These, supplemented by full explanations and full descriptions of the various kinds of tools and machines used in this kind of work, will be given from the most simple appliance to the most complex machines now in use. A full and detailed description of the various operations required and made use of in the building and construction of sheet-iron and steel-plate furnaces will be dealt with in due course.

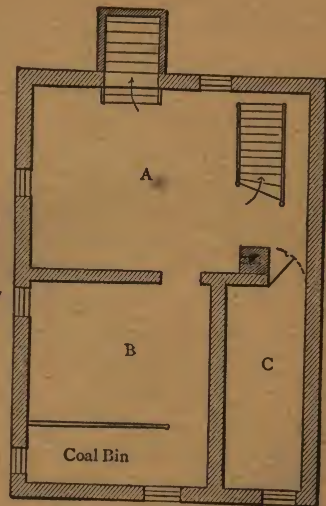
II.

THE READING OF PLANS.

The ability to read the plans or diagrams generally furnished by architects is very necessary and one of the most important factors to facilitate the correct measuring and figuring of furnace work. As this part of the work is the first consideration to be dealt with, I give in this paper the floor plan Fig. 1, the cellar plan Fig. 2, and these supplemented by the front elevation, Fig. 3, of a small cottage. It is understood as a matter of course, that the furnishing of plans by architects is usually the rule for new houses. In houses that have already been built, or old work as commonly termed, this is not often the case; the measuring of work and whatever diagrams or drawings are wanted have to be supplied by the furnace man himself.



FLOOR PLAN
Fig. 1



CELLAR PLAN
Fig. 2

FRONT ELEVATION.

The drawings from which work is figured and measured generally are drawn to scale. A foot reduced to $\frac{3}{16}$ inch, $\frac{1}{12}$ inch, $\frac{1}{8}$ inch or $\frac{1}{4}$ inch to the foot are the most in use; for detail work $\frac{3}{4}$ inch, 1 inch, $1\frac{1}{2}$ inch and 3 inches to the foot are the most convenient and generally used by architects. Ofttimes on plans the full dimensions in figures are given, but this is not invariably the rule. The plans here given are introduced $\frac{3}{4}$ size, from $\frac{1}{8}$ inch to the foot; full size dimensions are given in figures. A good exercise would be to draw the plans here given to a larger scale, say $\frac{1}{8}$ inch or $\frac{1}{4}$ inch to the foot; practice on this until thoroughly familiar with the different scales, so that when occasion demands it, any drawing can be easily read and understood, and also drawings or sketches can be made as the different phases in the practical work may require.

The different methods to ascertain the cubic contents of space in a house to be heated, as employed by different parties, may be classed under the heads of good, bad, and indifferent. Some furnace men use the very unscientific mode of merely counting the rooms in a house, guessing at their size, paying no particular attention to the various very important factors that enter into the proper consideration of the various exposed surfaces, such as the location of the glass surfaces, their exposure to winds, etc; then putting in a furnace about half large enough to do the work demanded, with the result of a very unsatisfactory job in the end. This mode I would consider as bad. A better way, but still rather indifferent as to correct conclusions and accurate measurements, is the mode of lumping of figures, or of guessing at averages.

Take the plan, for instance, measured from north to south, say is 38 feet long, then average the width from east to west, 20 feet. These figures give 760 square feet, floor surface; multiplied by the height of all the rooms 11 feet 4 inches gives 8,613 cubic feet as the contents of the house; this will readily be seen is entirely too great an estimate. The most satisfactory, and at the same time the correct way, is to go about this matter in a systematic manner. Get the floor area of each room; this multiplied by the height of each room gives the cubic contents of house. By the figures given in the drawings the following floor area of each room, and also its cubic contents are given.

The glass surfaces of each and all the combined totals are given:

Height of all the rooms in the clear 11 feet 4 inches.

	Size of Room.	Floor Area, Sq Ft.	Contents, Cu. Ft.	Glass Surface, Square Feet.
Parlor.......	11' 10" by 10'	151' 124"	$1722\frac{2}{3}$ cu. ft.	30 sq f. 2 windows
Sitting room......	12' 5" " 13' 4"	165' 100"		
Bay window......	5' $1\frac{1}{2}$" " 2' 7' 6" " 22"	24'	$2153\frac{1}{3}$ " "	60 " 4 "
Bed room.........	10' 2" " 10'	101' 96"	1154 " "	27 " 2 "
Kitchen..........	11' 9" " 13' 3"	155' 99"	1768 " "	30 " 2 "
Totals		598' 131"	6798 cu. ft.	147 sq.f. 8 windo's

The area of square feet, to use a whole number, I will take as 599 spuare feet. The deduction from this makes 6,798 cubic feet, or nearly 6,800. Eight windows give 147 square feet window surface.

To facilitate the ready calculation of the different areas, I will give further on some tables that especially apply to this work in particular. It will be observed that the cellar plan locates the same under the kitchen, bedroom and part of the sitting room. The letter A designates the summer kitchen and laundry. B is the furnace room and coal bins. C is the cold or storage room for vegetables, preserves, and such articles as would be affected by heat. The cellar is nine feet in the clear.

With each set of plans issued by an architect, a written or printed set of specifications is given. These generally give full and comprehensive descriptions of all points not shown in drawings. It is always good policy to note carefully every point described and implied therein so that when the work is to be done everything demanded is fully understood and provided for in the calculations. In measuring up work, see that an opening large enough to admit the furnace to be brought into the cellar is provided for, otherwise, one may sometimes encounter great inconveniences, which could perhaps have been avoided by a little foresight.

III.

RULES AND TABLES.

To facilitate and aid the ready calculation of plans, sketches and drawings that the furnace man has to deal with, I will here give some useful points and tables. The first fact to be ascertained when a set of plans are submitted to be figured on, is the location of the building. Note carefully its exposed surfaces, and, of course, the general character of its construction, whether of stone, brick or wood; its exposure to prevailing winds and the location of its different rooms in this regard. It makes a good deal of difference in the size of an apparatus that will be required to heat a given house, that is, say for instance, a house in a city block of houses, or a house of the same cubic capacity, but situated in a more exposed locality, as in the country, probably on a rise or upon a hill. Then note if it a well-built house. Of course it cannot be determined precisely from the plans how well a house is going to be built, or how poor a job will be done in its building, but it is generally safe to suppose that a house costing, say $5,000 will be better built than one of the same size costing, say $3,000, other considerations being equal.

Notice the peculiar construction of every room to be heated, its size, position of doors, windows, their size, position, whether single or double. See if provision has been made for ventilation. Note all flues in the house, their size, positions, if smootly plastered or not, or as is the case in ninety out of a hundred, whether they are filled up with hard mortar, from one foot to as in extreme cases I have found them filled almost five feet up from the bottom, left in this way by dishonest, or, to say the least, by culpably negligent masons. See if any fire-places or open grates are in the building; note the different flues running up in building in connection with the same. Pay particular attention to the thickness of the different partition walls; if wall pipes are to be used see if walls coincide or are directly above one another. This point has a very material bearing on the final cost and amount of labor necessary to do the work oomplete. It is also a very important item in the estimating of the total cost to know precisely who is to do the cutting of register-openings in the floors, if floor rugs are to be used, the moving of studding and other work which generally is done to suit the building, so that the different horizontal and wall pipes can be placed into their proper positions, as demanded for the best results and the proper heating and ventilating of the house. Of course some architects have the good sense to provide for some of these requirements, as location of register-openings, or for wall pipes, cold air inlet, and location of furnace, etc. But I may safely say that fully seventy-five per cent do not, and even in a great many cases where the architect has done what really is his duty, the builders, such as brick masons, and in particular the carpenters, rarely make their work conform to the requirements demanded by the furnace man for his work. The reason for this is very easily to be seen. For instance, take a set of plans of any building which is to be heated by a furnace; it will be seen at a glance at the various floor plans, that no provision is set where the carpenter must place his joists and studdings throughout the work. Of course he has the positions of the various openings in the walls for doors, windows, etc., to go by, but as to the rest of the walls he generally follows his own inclination, thus ignoring the very part that particularly concerns the furnace man's work, oftimes causing considerable expense and waste of time to the furnace man in case he is not watchful and careful to make provisions in his calculations beforehand to meet just such conditions. These remarks apply to new work in particular. I may also make the assertion, which will, I think, be borne out by most furnace men of experience, that most architects, to put it mildly, do not know as much about the proper arrangements of a heating plant as they really should, most of them leaving the arrangements entirely in the hands of

the furnace man; and these, it often is the case, lack a good deal from being perfect themselves in every particular concerning their work.

It is well to note and have a clear understanding with both the owner and also with the architect where the furnace is to be located, what kind of furnace is to be used, whether brick-set, cast iron or wrought iron; also what kind of wall pipes, whether floor or side wall register, concave or flat faced. Note the height of cellar, whether any excavation of cellar will be necessary; the disposal of earth as dug up. All these little items count and must be considered in the first step, namely the estimate of the cost of putting in the entire plant.

Have a definite mode and location agreed on from where the cold air is to be obtained. It of course is understood that the height of cellar in clear must be known.

Have a clear and well defined system of ventilation agreed on, if any fixed mode is to be used for obtaining this result.

Have an understanding how many persons are to live in, or are to use the building under consideration.

The foregoing does not by any means exhaust this subject, but will do for the preliminary figuring and estimating, and gives a good ground work to base further steps on which require a more detailed treatment which will be given further on as occasion demands.

The following tables and rules are often used in figuring areas, cubic contents, surfaces, etc., in furnace work.

It would perhaps be well to give in this paper the following arithmetical signs, which are used in calculations:

=	Signifies	Equality as	$4+4=8$
+	"	Plus or addition as	$2+4=6$
—	"	Minus or subtraction as	$3-2=1$
×	"	Multiplication as	$6\times6=36$
÷	"	Division as	$6\div2=3$
3^2	"	3 is to be squared as	$3^2=9$
3^3	"	3 is to be cubed as	$3^3=27$
$\sqrt{}$	"	Square root as	$\sqrt{16}=4$
$\sqrt[3]{}$	"	Cubic root as	$\sqrt[3]{64}=4$

The table given will be very handy in figuring the difference between the different pipes or surfaces, say, for instance, that area contained in the space between a radiator of a furnace and the casing is desired. The radiator being 4 feet and diameter of casing 4 feet 6 inches, by the table 4 feet = 1,809.56 inches area, and 4 feet 6 inches = 2,290.22 inches area, or in even numbers, say 2,290 square inches for casing and 1,809 square inches for the radiator. So 2,290 — 1,809 = 481 square inches area is contained in space between radiator and casing. Or in other words, to find the area contained between concentric circles of different diameters as mostly used in furnace work, this table covers almost any case that is liable to occur.

AREAS OF PIPES.—ROUND PIPES.

The diameter of a pipe being 1″ the area is .7854″, multiply the square of the diameter in inches by 7854 = area.

Diameter of Pipes.	Diameter of Pipes.
3″² × .7854″ = 7.068″	34″² × .7854″ = 907.922″
4 " " " " 12.566″	36 " " " " 1017.87″
5 " " " " 19.635″	38 " " " " 1134.12″
6 " " " " 28.274″	40 " " " " 1256.64″
7 " " " " 38.484″	42 " " " " 1385.44″
8 " " " " 50.265″	44 " " " " 1530.53″
9 " " " " 63.617″	46 " " " " 1661.90″
10 " " " " 78.540″	48 " " " " 1809.57″
11 " " " " 95.033″	50 " " " " 1963.60″
12 " " " " 113 097″	54 " " " " 2290.22″
13 " " " " 132.732″	56 " " " " 2463.01″
14 " " " " 153.938″	0 " " " " 2927.44″
15 " " " " 176.715″	62 " " " " 3019.07″
16 " " " " 201.062″	64 " " " " 3216.99″
18 " " " " 254.469″	6 " " " " 3421.20″
20 " " " " 314 160″	68 " " " " 3631.68″
22 " " " " 380.133″	70 " " " " 3848.46″
24 " " " " 452.290″	72 " " " " 4071.51″
26 " " " " 530.930″	75 " " " " 4417.87″
28 " " " " 615.753″	78 " " " " 4778.37″
30 " " " " 706.860″	80 " " " " 5026.26″
32 " " " " 804 249″	84 " " " " 5541 7824″

The table given for the areas, is, of course, as precise as will ever be needed for correct calculations, but where it is preferred, whole numbers will be near enough for all ordinary cases in practice.

The following are also important rules which are frequently made use of:

1. The area of a circle by rough calculations, may be taken at three-fourths of the square of the diameter. Note this method, a quick, but not precisely accurate one, is often made use of.

2. The diameter × by 3 1416 = circumference.

3. × the circumference by .31831 = diameter.

4. × the square root of the area by 1.12827 = diameter.

5. × the side of a square by 1.128 = the diameter of a circle of equal area.

6. × diameter of a circle by .8862 = side of an equal square in area.

7. × diameter of a circle by .7172 = side of an inscribed square.

8. The areas of circles are to each other as the square areas of their diameters. Any circle whose diameter is double that of another contains four times the area of the other.

9. × circumference by .2821 = side of an equal square.

10. × circumference by .2251 = side of an inscribed square.

11. × side of a square by 1.4142 = diameter of its circumscribed circle.

12. × side of a square by 4.443 = circumference of its circumscribed circle.

13. × radius of a circle by 6.28318 = circumference.

The following gives the linear, square, cubic and angle measure tables used in furnace work:

Linear.	Square.	Cubic.
12″=1′	144 sq. ″=1 sq. ft.	1,728 cu. ″=1 cu. ft.
3′ =1 yd.	9 sq. ′ =1 sq. yd.	27 cu. ′ = 1 cu yd.

The square measure is used to measure length and breadth. One square foot is a square, each side of which is a linear foot, used to measure surfaces, areas, etc. The cubic measure is used to measure length, breadth and thickness; in furnace work the cubic contents of space of rooms, etc.

The area of a triangle is one-half of the product of its base and altitude. As for instance, a triangle whose base is 8 feet, and altitude 5 feet, has an area of $\frac{8x5}{2}$ = 20 square feet. This last rule is used in measuring corners in bay windows, etc., by it, also, all polygonal areas are calcua sted.

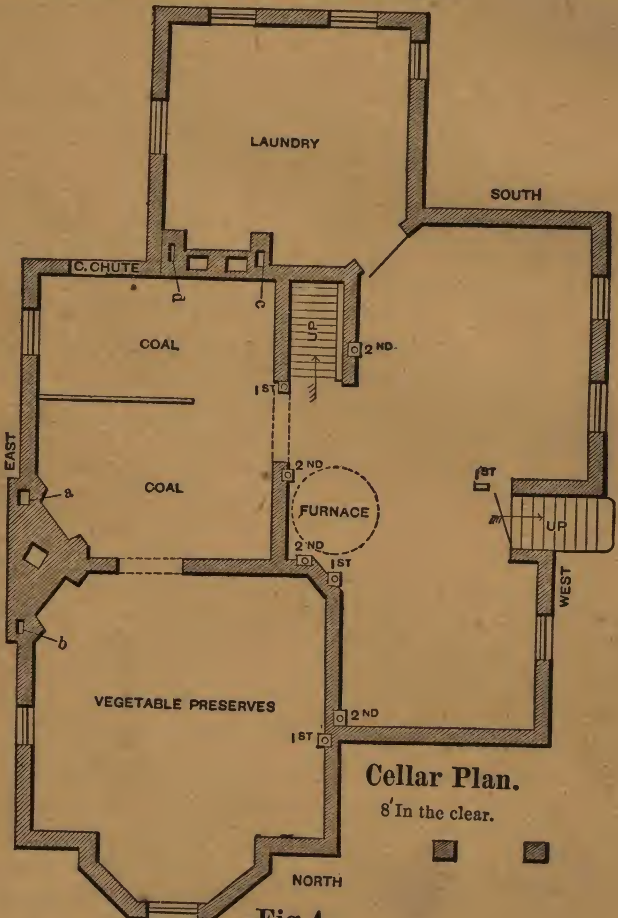
The tables of areas of oval and square pipes will be given in a future paper.

IV.

MEASURING OF WALL PIPES.

The plans submitted in this article are those of the first and second story of a frame building; the cellar plan is also given. The dimensions as to the length and width ot each of the different rooms are marked on the plan of each room. The walls of the cellar are of brick and the outside walls are 12″ thick; the inside walls are 9″ thick. The height of the cellar is 8′ in the clear on the inside. The floor is to be of concrete, and the ceilings of all the different apartments of the cellar are to be lathed and plastered. The floor joists of first floor are 12″; the height of the first floor rooms is 9′ 6″ in the clear. The floor joists of second floor are 10″ and the rooms are 9′ high in the clear. All the windows of the cellar are made to hinge from the top, to be raised for flushing the laundry and cellar with air for summer ventilation. It will be noticed that the chimney on the east side has three open fire places connected with the central flue. The

two first floor fire places discharge into the divided flue; see first floor plan, Fig. 5. The divided flue unites into one central single flue at, or near floor line of second floor, Fig. 6. The flue a is intended for furnace smoke flue, and the flue b is for ventilating flue for the cellar.



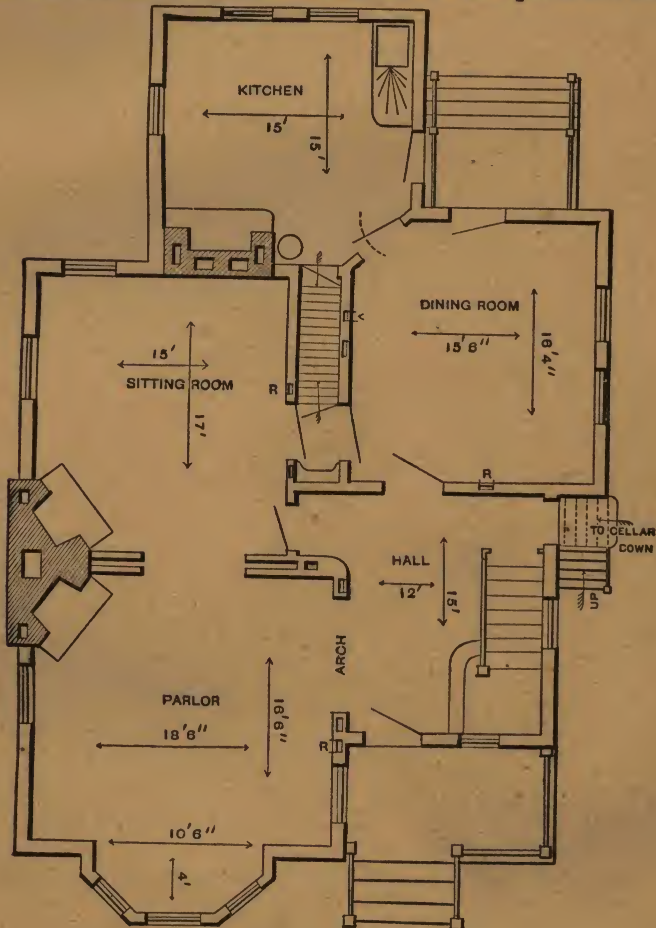
Cellar Plan.
8' In the clear.

Fig.4

The plan of the second floor shows the connection of fire place on that floor with the central flue. The rear chimney has four flues; the two central flues are one for the kitchen and the other for the laundry smoke flues. The flue c is for hot air duct for the rear chamber of the second floor. Flue d is intended to be used to ventilate the two chambers immediately adjoining flue d. The bath-room and the southwest chamber of second floor are to be ventilated by vent flue located in the dividing wall between the two

rooms at v v. The closet x is to be ventilated by vent flue as shown on plan.

I will assume that the plans Figs. 4, 5 and 6, are submitted to a furnace man to be measured up for all the square hot air pipes required for the building, and also for the ventilating pipes as the plans call for.

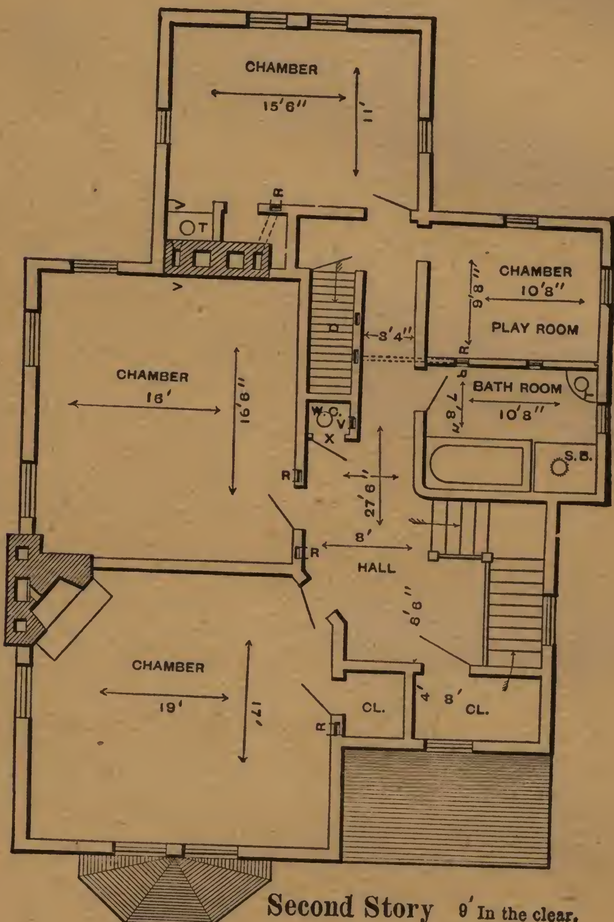


First Story 9'6" In the clear.

Fig. 5

In the plans given, the positions assigned to the various pipes I will say have been fixed by the architect. All the registers throughout the entire house are to be put in the side walls. The place where the furnace is to be set has also been designated by him as well as the direction for the cold

air duct. At the present time I will not discuss the propriety of the various positions assigned to the furnace, hot air pipes and ventilation ducts by the architect, or his reasons for doing so, but will show how to proceed to get the measures as the plan demands.



Second Story 9' In the clear,

Fig.6

The first step for a rough calculation in order to get the figures for estimating the total amount of pipe required, so as to obtain its cost, is as follows: For first floor rooms take the distance from bottom line of plastering of cellar ceiling to the top of pipe, as required for the proper placing of the wall registers of first floor rooms and hall.

The details are as follows:

1.	Thickness of lath and plastering of cellar ceiling is.....	1 ″
2.	Height of floor joists is..............................	12 ″
3.	Thickness of flooring is.............................	$1\frac{1}{4}$″
4.	Height of base board and molding is...............	$10\frac{3}{4}$″
5.	Height from base board to lower end of register edge...	2 ″
6.	Make pipe 2″ longer than size of register measures. If 12″ make the same.............	14 ″
	Total.................................	41″

The opening demanded by a register without a frame is $\frac{1}{4}$″ larger than register measures; for a wall pipe, as, say a 10″ by 14″ register is to be used, the opening should be $10\frac{1}{4}$″ by $14\frac{1}{4}$″ to ensure a nice easy fit. The reason I give for a register measuring 12″ only, an allowance of 14″ of pipe is, that the register when in position on the wall should never be any lower than two inches above the top of molding of base board; this, to make a neat finish in the setting, and also as the register has a flange extending from 1″ to in some cases $1\frac{1}{2}$″ farther out than the opening in the square pipe. This opening is generally made an inch down from the top of the pipe, so that when the register is placed it extends one inch farther out all around beyond the size of the opening of the pipe and wall. These reasons if the pipe is made 2″ longer still leave 2″ of space of wall exposed above the molding of the base board and the lower edge of flange of register. As there are four pipes to be supplied for first floor, namely, one each for parlor, hall, sitting-room and dining-room, we have 4x31″=10′ 4″ pipe required for the first floor rooms. It is to be borne in mind, that for each supply pipe of each separate room, the lower shoe and the opening are extra, although both are included in the total length of each pipe or stack, as the wall pipes of houses are commonly called. I have also omitted to give the capacity of the different sizes of pipes. What I want to impress first is how to measure the length of a stack and not the details; these will be given farther on.

There are four stacks for the second floor, but five rooms to be heated; that is, one of the stacks is to supply the hot air for two separate rooms, namely, the bath-room and the south west chamber. The south chamber, it will be seen, is supplied by the duct c, Fig. 4, of rear chimney. We will first consider the front or northeast chamber stack.

Details of the N. E. chamber, square pipe or stack.

1.	Thickness of lath and plaster of cellar ceiling is........	1″
2.	Height of first floor joists are........................	12″

3. Thickness of first floor flooring is.................. $1\frac{1}{4}''$
4. Height of first story rooms is......................... 9′ 6″
5. Height of 2d floor joists are.......................... 10″
6. Thickness of 2d floor flooring is...................... 1″
7. Height of 2d floor base board and molding is........ 9″
8. Height from base board to lower edge of register is..... 2″
9. Make the pipe 2″ longer than the measure of the register; if the same is 12″ make the pipe........................ 14″

Total length of pipe.......................... $13'\ 8\frac{1}{4}''$

Add to the above total one starter or shoe and one register opening, all included in the total length of stack.

The measure of the length of the upper hall stack is the same as that for the N. E. chamber.

The measure for S. E. chamber stack is also the same as the N. E. chamber stack.

The stack which supplies both the bath-room and play-room has an additional length of square pipe under the floor, connecting the two vertical sections as the second story plan, Fig. 6, shows. The length of this section is 6′ long, making the total length of this stack $13'8\ \frac{1}{4}'' \times 6 = 19'8\frac{1}{4}''$ long and two turns, register opening, and shoe extra. The connection pipe for the south chamber from the flue c to wall is 3′ long, the vertical parts are 2′ 2″ long, making the total length of this stack 5′ 2″ long, register opening extra.

The foregoing gives for the total of all the first and second floor hot air supply stacks as follows.

4 first floor stacks each 41″ long=.................... 13′8″

For second floor stacks.

1. Length of N. E. chamber stack is.................. $13'8\frac{1}{4}''$
2. Length of S. E. chamber stack is.................. $3'8\frac{1}{4}''$
3. Length of hall stack is............................ $13'8\frac{1}{4}''$
4. Length of B. R. and P. R. stacks is............... $19'8\frac{1}{4}''$
5. Length of S. R. stack is........................... 5′2 ″

Total of all H. A. stacks...................... 69′7″

Charge extra for first floor pipes 4 shoes or starters.
Charge extra for second floor pipes 4 shoes or starters.
Charge extra for second floor pipes 6 register openings.
Charge extra for first floor pipes 4 register openings.
Charge extra for B. R. and P. R. floor pipes 2 elbows.

The above is the total of extras on hot air stacks of entire house.

For ventilating pipes for the first floor rooms we have only to consider the dining-room as the plan shows. The hall it is intended to ventilate to the furnace. For the parlor and sitting-room the open fire places are intended for vent ducts of these rooms. The kitchen ventilation will be attained by the use of a canopy; the smoke flue of the kitchen stove will be utilized for this purpose. The details of ventilation pipe for dining-room are as follows, as to its length :

1.	Height from floor of dining-room to ceiling is........	9′ 6″
2.	Height for 2d floor joists and flooring is..............	11″
3.	Height from floor of 2d story to ceiling is............	9′
4.	Height of thickness of lath, plaster and ceiling joists of 2d story is..	10″
5.	The distance from vertical vent pipe to flue in rear chimney is...........	7′
	Total length...............	27′ 3″

1. Charge extra for register openings at floor of dining-room.

2. One elbow for vent pipe. This elbow occurs where the section of pipe which enters the brick vent flue joins the vertical which comes up through the wall which divides the stairway and rear hall, Fig. 6. The ventilating pipes for the second story are, one pipe to ventilate both the bath-room and play-room. The S. E. chamber ventilates into flue d of rear chimney. The south chamber does the same. The length for south chamber vent pipe is 3′ and one register opening. The register opening for the S. E. room will be made directly into the brick work. The closet (marked x) pipe is 9′ 10″ long vertically and 14′ long from vertical pipe to flue d of the rear chimney. Total length of same is 23′ 10″. One register opening and one elbow are to be charged to this pipe:

The vertical height of bath-room and play-room vent pipe is 9 10″ and from vertical to flue c of rear chimney is 18′ long; total length of same is 27′ 10″. Two register openings and one elbow are to be charged to this pipe.

Total lengths of ventilating for entire house.

	For first story vent pipes length of dining-room pipe is....	27′ 3″
	For second story vent pipes.	
1.	Length of south chamber vent pipes	3′
2.	Length of closet x vent pipes is.......	23′ 10″
3.	Length of bath-room vent pipes is................	27′ 10″
	Total..	81′ 11″

Charge extra for first story ventilating:

Register openings.................... ....,........	1
Elbows for first story..............................	1

Second story register openings	3
Second story elbows	2

The foregoing amply shows how the lengths of stacks and ventilation pipes are measured for the purpose of preliminary figuring.

V.

DETAILS OF WALL PIPES.

In measuring up stack work for a house as the figures 5 and 6, article IV, give, great care is to be taken to get every detail as correct as possible while the work is done in the shop, so that when the work is put into the building everything fits snug and just right. To attain this result it is absolutely necessary that the measures taken by the person doing this work are also correct and in such shape that they can be readily understood and easily read by the men in the shop.

Figures 7 to 14 give example of drawings of stacks and details of work of this kind.

The Fig. 7 A gives a west end view of the stack supplying the 2d story hall; B is the south front view of same.

It will be seen by the plans that the lower section, or that part running up between the partition wall of the first story, stands at right angles to the upper end, which discharges into the upper hall.

The drawing shows all the relative positions clearly of the entire stack, and is drawn to $\frac{1}{4}''$ scale to the foot. In length it corresponds to the measures given in the table of the hot air stacks, article IV.

In practice it is not necessary that the entire figure be drawn, of course, the general mode of obtaining the memoranda of a stack of this kind being to put down the height of joists of first floor, then from this point to the bottom line of upper floor, and from there to the top of stack, as the following figures give: $12''+10'\ 6\frac{1}{4}\times 2'\ 2''=13'\ 8\frac{1}{4}''$. The turns and deviations from a vertical line between the second floor joists can readily be seen by the drawing, as shown by the positions of plan in Fig. 7. Although the notation being shorter than by the first mode given, it must not be forgotten that all the details given in Fig. 7 have to be allowed for to obtain the correct result. The shape of the shoe or starter given in Fig. 7 is a very good one for this case and the conditions as the plans of Figs. 5 and 6 of article IV. call for. The following are the details and explanations of the letters in Fig. 7: A is end view of stack, B is side or front view of same, L and P for lath and plaster for both ceiling of cellar and first story room, J for joists for both floors, F. F. S. and F. S. S. for first and second story floors, B. B. for base boards, R. O. for register opening in stack.

Fig. 8 gives an end view of the hot air supply stack of the N. E. chamber. Every detail is plainly marked on the same. The scale is $\frac{1}{4}''$ to the foot.

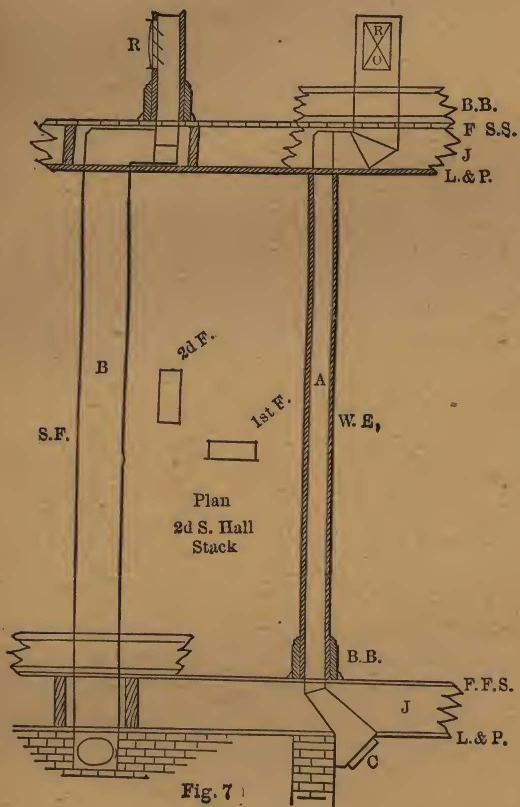


Fig. 7

Fig. 8

Fig. 9 shows the positions of the end and side views of the first floor stack which supplies the parlor with hot air. N. E. E. is the northeast end view and E. F. V. is the east front view, J. are the joists, B. B. baseboard, M. the mouldings, R. O. register opening, F. floor, S. S. are studdings and C. the inlet collar of the stack in the cellar. This figure is drawn $\frac{1}{2}''$ to the foot.

Fig. 10 shows a broken view of the hot air supply pipe of both the bath and the play room of second floor; A is the vertical pipe located in the partition wall between the dining room and stairway, B is the horizontal section between the outlet section between the play-room and bath-room, c is the outlet section. An end view is also given of the manner in which the two openings are to be placed in relation to each other. It will be seen

that a dividing shield is placed between the two openings; this should extend below the lower edge of the register opening from six to ten inches at least, and placed into the stack as shown in drawing.

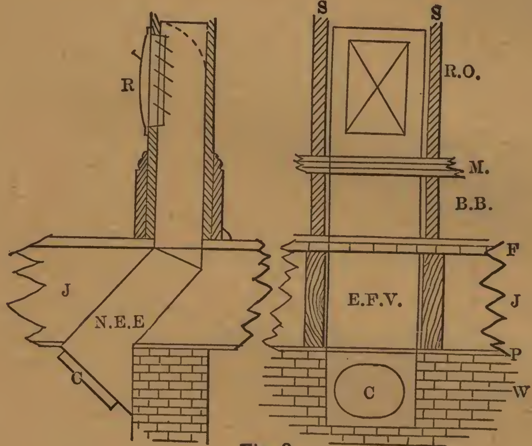


Fig. 9

It will be noticed that at the upper end a deflector shield is put into the stack, shown by dotted lines; this gives the flow of air a gentle curve to the outlet at the register instead of an abrupt turn, which would be the case without it. I would recommend to put a shield of this kind into every stack, which has its outlet on the side. A more detailed description of the different styles and kinds of hot air stacks will be given farther on.

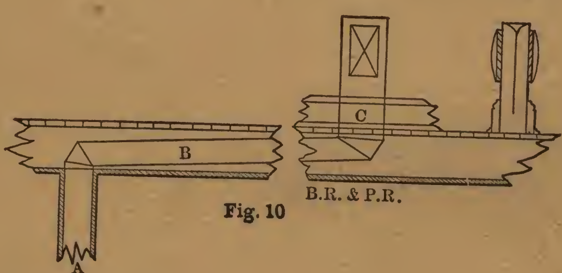


Fig. 10

Fig. 11 shows the details of the ventilating pipe or stack for the bath-room and play-room. A. is the vertical pipe, with the two vent registers placed in position, opposite to each other. A dividing shield is placed in the stack as shown in the bottom end between the two registers. B. shows how the end which enters the ventilating flue is to be arranged.

Fig. 12 gives the manner of placing, and the general arrangement of the inlet of the ventilating flue of the southeast room. The Figure 12 gives this arrangement so plainly that no further explanation is needed for this figure.

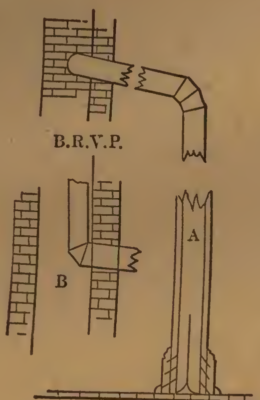


Fig. 11

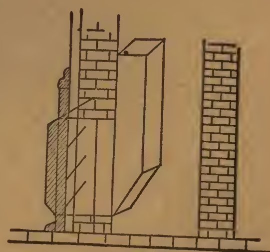


Fig. 12

Fig. 13 shows the general style and shape of the shoe for the dining-room stack. This is to be used instead of the kind used on the other stacks in this case; there being no turns, but a straight line only, this style is the best.

Fig. 13

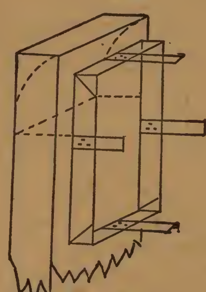


Fig. 14

Fig. 14 gives the style of the outlet or register openings made use of on this occasion. The dotted lines show position of curved shield at the back and top on the inside. The strips riveted to the side of the register opening are used to fasten the registers to the side wall. The manner in which this is done is as follows: The stack being in position and the walls plastered and finished, trim the outlet flush with the outside finish of the wall, then take off the register face from register, put the register frame into the opening of stack, bend the strips over the frame and tightly to its sides,

trim off the ends if too long, be sure to have the frame about a quarter inch back from face of finished wall, then put the register face against the wall in its right position, corresponding with the position of the frame of the register, and bolt same together with the register screws or bolts. The frame being held in place by the straps of stack, as a consequence the tighter, the bolts are drawn up the firmer the face of the register becomes fixed with its flanges against the wall.

VI.

MEASURING OF ROUND PIPES.

To get the correct estimate of the actual amount of round pipes it requires to pipe a furnace, I would recommend the following method for the preliminary part to attain this result. Take the plan of the cellar in Article IV, as given by the architect. It will be seen that the final position of the furnace and its location in relation to the inlets of the various stacks, has been set by him.

Fig. 15 shows the plan of the furnace located in cellar plan of Article IV, also the positions of the walls as far as is necessary to show the correct location of the starters of the wall pipes, etc. Now from the

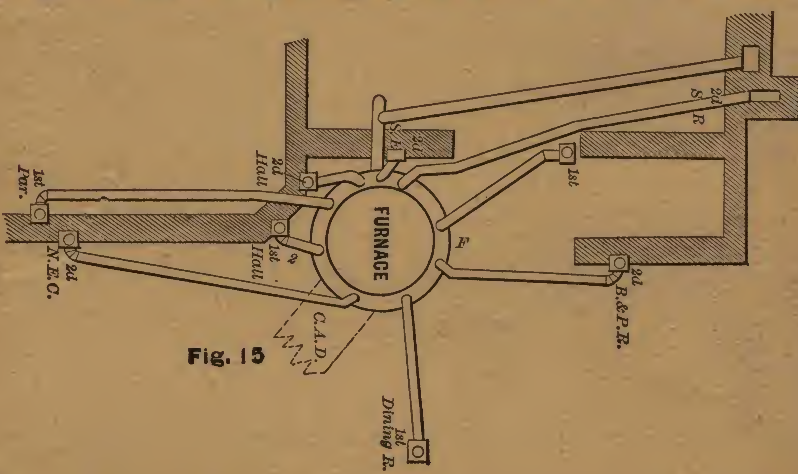


Fig. 15

furnace to these various starters, draw the respective round pipes as is fully shown in Fig. 15. For ready reference, I have marked each starter, to which room it leads and also the location of same on each floor.

Fig. 16 shows the correct elevation of each pipe which it assumes when it is placed in position as demanded by the plan, Fig. 15.

By thus drawing both the plan and elevation, it becomes a simple

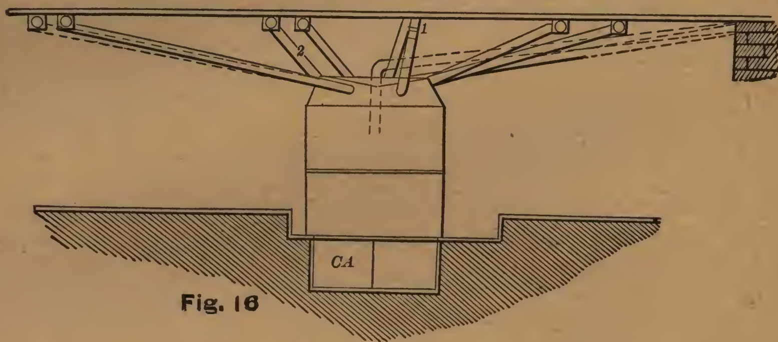


Fig. 16

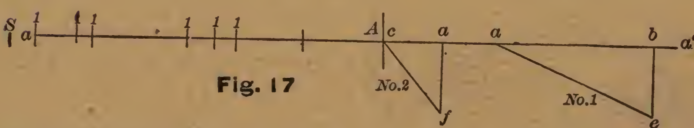


Fig. 17

matter to ascertain the true length of each pipe. Take, for instance, the dining-room pipe, marked 1 in Fig. 15, and also the pipe leading to the second story hall, marked 2. Take the distance from their respective starters to the furnace, transfer these to a line drawn to any indefinite length, as the line a a′, Fig. 17, as shown for line 1 by the distance a b, and for the line 2, by the distance between c and d on line a a′. From b drop the perpendicular line b to c equal in length to the height of the rise of the pipe from the furnace hood to the starters, as is fully shown in Fig. 16. Do the same at d to f for pipe No. 2. Then the distance from a to e is the actual length of pipe No. 1, and from c to f is the length for pipe No. 2. It will be observed that the actual lengths for all the pipes are marked on line a a′. from A. to a, which have all been obtained in the same manner as described above.

This operation described in geometrical terms would be: ascertain the length of the two sides of a right angle, or the base, as b c, and the perpendicular, as b a; the ends of these connected by a line called the hypothenuse gives the true or actual length of the pipe under consideration.

A drawing by this method, as Fig. 15, if drawn correctly to scale of any job of this kind, gives at once a correct and simple record of the entire work of piping a furnace. If each job is drawn out into a book, say one page devoted to each separate job, much time and annoyance may often be saved, when, as is often the case, some particular point

or item is wanted to be known about work done, but which generally nobody about a shop can remember to a certainty. To keep a book of this kind would pay.

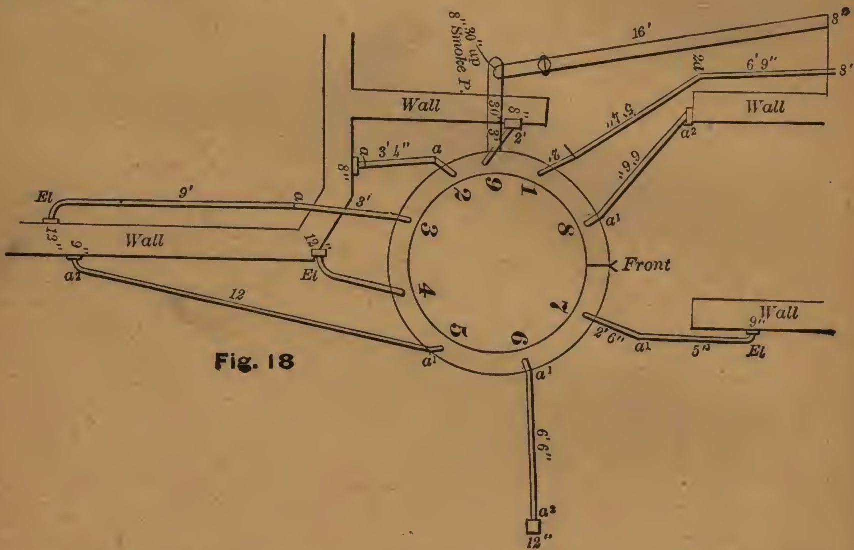


Fig. 18

The foregoing covers all that is necessary to form a reliable estimate as to the amount of pipe it will take for the furnace as the plan of cellar, Article IV, demands.

I will now assume that the furnace has been set up in the cellar and is ready for the pipes to be put up and connected.

One of the most crude, and in my opinion, unworkmanlike ways of going about this work, is to send a lot of pipes of the different sizes that may be used to pipe the furnace, and also a lot of different angles and elbows, without any regard as to whether they have anyway near the right angle demanded to make a neat and good job. I have seen cases where say ten angles were actually used, and thirty sent out from the shop, and as a matter of course, as the workmen are not over-careful sometimes, the natural result was that this mass of stuff laying around all over the sometimes not over-clean cellar, and often being in the way of the workmen, was stepped on, smashed and generally battered so that they were hardly fit to be used. It also often makes it necessary to do extra hauling and teaming, which could have been avoided by some sort of system and order. All this shows poor judgment and bad management of those who should know better. A far better plan to follow is fully shown by Figs. 18 and 19. When the furnace setter has the furnace proper set up

and it is ready for piping, the collars for the hood should be at hand. Space off the hood as demanded for the best results for the easy and equal flow of the hot air, so as to insure each pipe its proper share, to heat the apartment it is to supply.

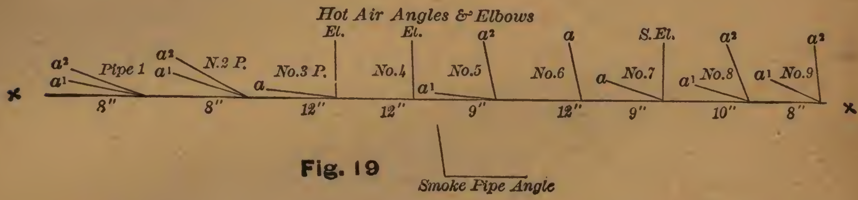


Fig. 19

When the hood is spaced off, cut the holes for the collars and trim them so that they will conform as nearly as possible to a straight line from the furnace to the starter of the stack. Care must be taken not to cut too large an opening out of the hood. As for instance, if a 9″ collar is given as much as it will be possible to trim it on a slant against the side of a furnace hood, the opening may be larger than a 10″ or 11″ collar would require put on, straight out from the hood. The idea is not to go to the extreme, but to secure as straight a line to the starter as is consistent for good judgment to take. Fig. 18 gives some examples of what is meant.

After all the collars are trimmed and holes cut in the hood, fasten them temporarily and make a mark on both the collars and hood so that when they are taken off, they can readily be put in the same place again without any trouble to find out just how they were on before. Also number them, both the collars and the openings in the hood to which they fit. The tools required for the proper measuring of this work, are a tape line and a bevel angle, a rule, and paper and pencil.

Mark down on paper a circle like Fig. 18 gives for furnace. The workman need not be over-particular if he does not get this part so nice looking and precise as the figure given. The part where he wants to be precise is for the angles and elbows; the sketch he makes is only to guide him where the work he gets out goes when he puts up the same. I will first take the pipe No. 1: stretch the tape line from the collar of the furnace to the outlet in the hot-air flue, mark down on the sketch the length as obtained, which is 6′ 9″ and 5′ 4″ and 2′, then get the bevel of the angles as Fig. 19 shows. To put these down, draw a straight line as × . ×′. shows; mark the angles obtained as shown for pipe No. 1, and number them as shown in both Figs. 18 and 19. Mark the size of diameter underneath the line × ×′. as for pipe No. 1, marked 8″. By a careful study of Figs. 18 and 19, it will be seen that the foregoing has been applied to all the other pipes in the same manner. Of course all the angles are obtuse angles in this

case. The sketch here given has all measurements put down for each and every particular point needed to be fully understood. The pipes are all numbered on the hood of the furnace; their diameters are given at the other ends, as No. 5, is marked 9″ on the other end of same.

No. 6, is 12″, etc. The length of each pipe is plainly shown at each pipe and their respective angles and elbows are fully given by Fig. 19, also their diameters. This much for measuring the work-up where the furnace is set. To get out the work in the shop, the following list has been deducted from the foregoing. The collars will have to be taken to the shop and turned up and cleats riveted on the inside to fasten same to their openings in the hood when the piping of the furnace is put up.

The amount of pipe required is:

8″ Pipe.	For No. 1	13′	10″
	" " 2	3′	4″
	" " 9	3′	
		20′	2″
9″ Pipe.	For No. 5	12′	
	" " 7	7′	6″
		19′	6″
10″ Pipe	For No. 8	6′	6″
12″ Pipe.	For No. 3	12′	
	" " 4	3	
	" " 6	6′	6″
		21′	6″

8″ Smoke pipe.	1 Piece	2′ 6″ long
	1 "	2′ "
	1 "	16′ "
	1 Angle elbow	
		20′ 6″

PIPE ANGLES.

Angles	6	8″
"	3	9″
"	2	10″
"	2	12″

ELBOWS.

Elbows	1	9″
"	2	12″

DAMPERS.

Hot air pipe dampers	3	8″
" " " "	2	9″
" " " "	1	10″
" " " "	3	12″
Smoke pipe damper	1	8″

HOOD COLLARS.

Hood collars	3	8″
" "	2	9″
" "	1	10″
" "	3	12″

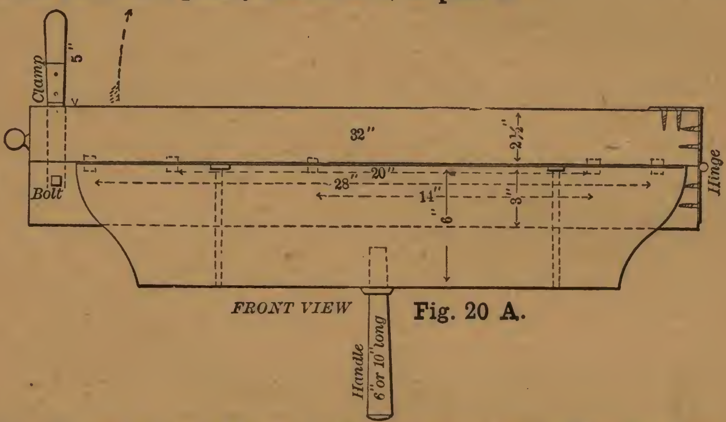
VII.

TOOLS FOR BENDING SQUARE PIPE.—MACHINE No. 1.

A description of the various kinds of tools and machines, the ways of making and forming the different styles and kinds of hot air wall pipes, will next be given. Tables and useful rules applying to the different square or rectangular pipes, both single and double, and also for oval and round pipes, will be fully given in a form most suitable for measuring and getting out stack work in the shop.

The different methods and tools used in most shops for bending the corners of square pipes are, first, with the beakhorn stake. This is about the slowest and at the same time the most laborious way of doing the work. I may add that this way of doing the work is not used, excepting in rare cases, in well-regulated shops where economy of time is considered. In the larger furnace shops special machinery is provided for the workingmen to do the work with. These tools and machinery are costly, and the more complicated the higher the price. For the benefit of those that do a good deal of work of this kind, but do not feel inclined to buy the higher priced machines, I give the designs of two machines that will answer all the purposes required, being light, strong, durable and cheap, and that can easily be made by any mechanic of average ability. The views A, B and C, of Figure 20, give the front elevation, plan and end view of a brake or machine for this purpose. The bed plate or main body of the machine is made of a 3″ thick, 4″ wide and 32″ long piece of hardwood. The clamp or top part is 2½″ high, 2½″ wide at the bottom and 2″ only at the top in width. This part is also made of hardwood, as is also the lever, which is 30″ long, 6″ wide and 1½″ thick where it joins the bed plate, as L of the end view of C. The reason for the length given is that 30″ wide material may be worked with this brake if so desired. I will first describe how the bed-plate is to be put into shape. Have all the sides

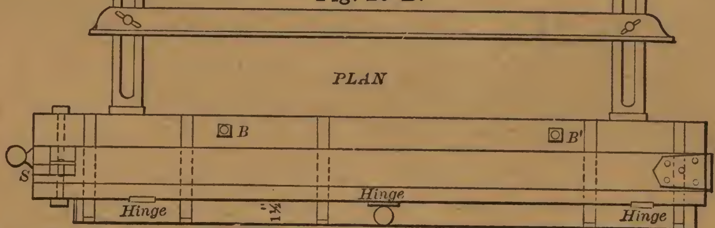
placed and smooth; next cut the grooves on the upper face of the bed-plate ½ inch wide and ⅜ inch deep, corresponding to the measures given in A and plan B. These grooves are made to allow the folded part of the pipes to be turned and at the same time not to crush them flat when the clamp is fastened down. The grooves correspond to the distances required for 14″, 20″ and 28″ pipes. Next face this part with plates of iron between the grooves, first cutting out a slot on the left end for the fastening bar of the clamp as shown by the plan B and by the end view C. This slot is to be ⅜″ wide and 2″ back, starting from the end of the bed-plate; the exact position is plainly shown at S, of plan B.



FRONT VIEW **Fig. 20 A.**

Next bore the holes for the ½″ bolts that hold the machine fast to the bench, as at B, B″, of plan B. Cut the clamp, or top part, and make to the dimensions given in the drawings. Cut out the grooves to correspond with those of the bed-plate, both for spaces for the folds of the tin pipes,

Fig. 20 B.



and also for the fastening bar. Line the faces of the clamp that come in contact with the material worked while in use with iron plates of moderate thickness, say about 1-16″ thick. The lever, wing, or bending bar, of which the front view A gives full dimensions, and also the general style of the shape most suited for the same, has also grooves cut out of its 1½″ wide

end to admit the passage of the folded part of the tin pipes. A handle, as shown in the drawing, is the best shape for the lever, and I would advise that one of this shape be used for this purpose. The face of the lever is also to be lined with iron strips. The different parts are now ready to be put together. Place them together in their relative positions and mark off on their surfaces the positions of the different sets of hinges. The lever is shown, in both the plan and front views, let down when not in use; in the end view it is shown as up, or as it appears when in use or when making a square bend. The top clamp is joined to the bed-plate on the right hand end by a heavy hinge; this hinge should be of the best kind that can be procured, and well bolted or fastened on to the two pieces of the machine with long screws. The lever may now also be hinged on to the bed plate; the position and number of hinges is plainly shown by the drawings A and B. The next step is to put the tightening clamp in position; this clamp may be of $\frac{1}{4}''$ by $1\frac{1}{4}''$ iron. A side lug, as the end view C gives, is to be riveted to this as is shown. The lug so fastened holds down the top

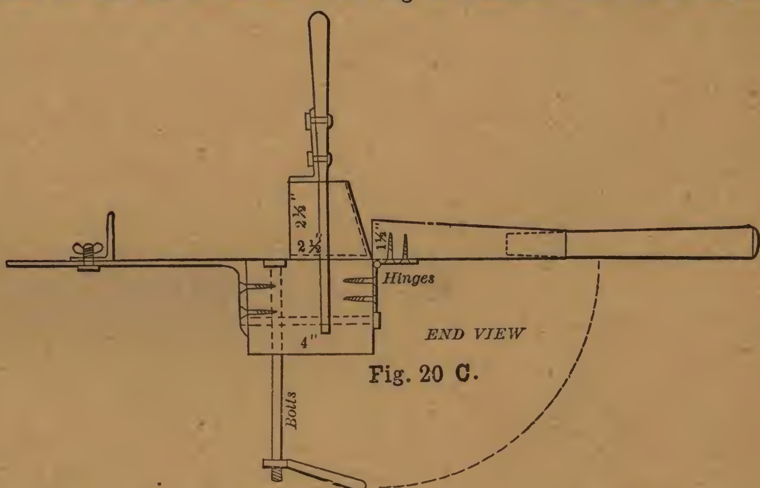


Fig. 20 C.

clamp to the material while the machine is in use. The position of the bolt which holds the tightening clamp in position is shown by all three views. A handle or knob to lift the top clamp from the bed-plate is also to be put where the drawings show. The dotted lines are the directions in which the different parts of the machine lift and work; these are given in the front and end views. The gauge bars, as shown by the end and plan views, may be made as suits the fancy. Plan B and the end view C show fully what is desired. A machine made after the description given in the foregoing need not cost more than five dollars. This covers all the material, time and labor needed for its construction.

VIII.

PIPE BENDING MACHINES—No. 2.

Fig. 21 shows another style of a home-made pipe-bending machine. The main parts of the machine are made of hardwood; all the wearing edges are lined with iron strips similar to the style described for the machine in Fig. 20. A is the plan and B is a side elevation. Full dimension figures are given on both the plan and side view. The directions in general, given for the construction of the machine, Fig. 20, also apply for this one, and therefore need not be repeated in this case. The following is a full explanation of all the different parts constituting this machine. C is the bed plate, to which the gauge bars or guides are attached as shown by G. The

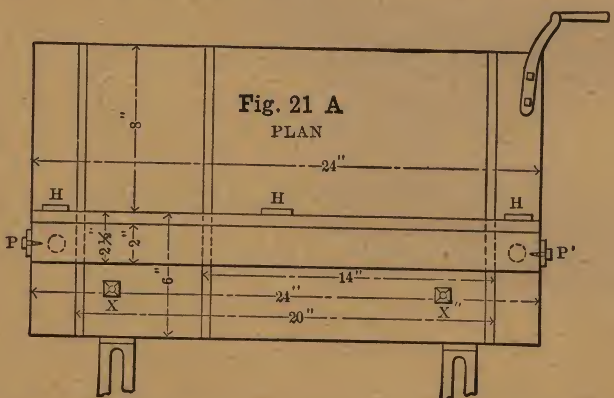


Fig. 21 A
PLAN

bed plate is bolted to the bench by two ½″ bolts shown by x of side view B, and also by x, x′ of the plan A; the brake wing is hinged to the bed plate by three heavy hinges as shown by the plan. Grooves are cut out of both the bed plate and the brake wing, to allow room for the folded parts of the square pipe; these grooves are one ¼″ deep and ½″ wide. A handle, as shown, is to be placed in the position given by the drawings. The top clamp E of end view is held up off from the bed plate by two strong spiral springs. The end view shows how deep each end of these springs is to be sunk into the wood, and the plan shows the location of each spring by the two dotted circles, one at each end of the top clamp bar. These springs are to lift the clamp bar ½″ in the clear off from the bed plate. The clamp bar is to have grooves cut out from its bottom side to correspond to those

of the bed plate. At each end of the top clamp bar a $\frac{1}{4}''$ x $1\frac{1}{2}''$ piece of iron is to be securely fastened; these pieces are to be long enough to extend about two or three inches below the bottom side of the bench, upon which the bed plate of the machine is fastened. A $\frac{1}{2}''$ hole is to be put in the lower end of each of these pieces. All this is plainly shown by P of the end view and P, P′ of the plan. The foot treadle S of B is fastened to the floor at the front edge by a hinge as shown; the other end is connected to the pieces P of the machine by rods, as is fully shown by the end view B.

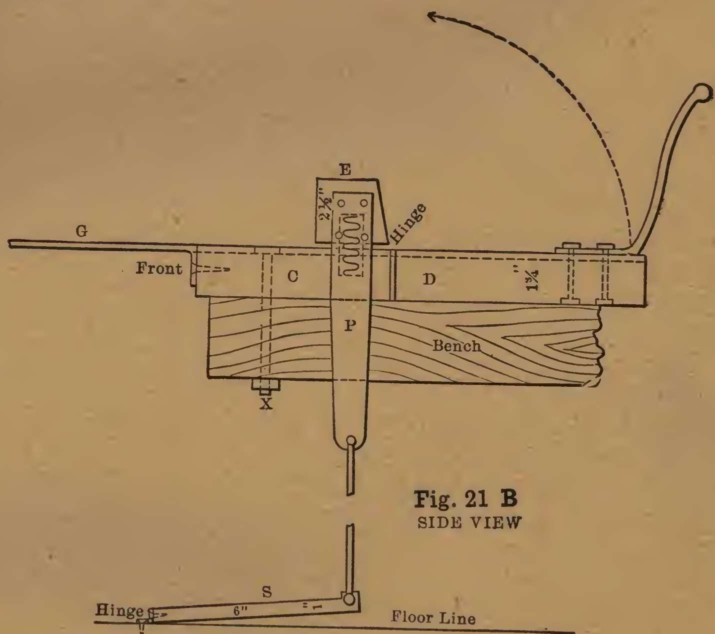


Fig. 21 B
SIDE VIEW

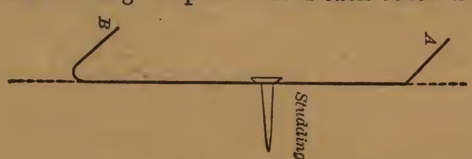
When the machine is not in use the springs in the top clamp bar draw the treadle up $\frac{1}{2}''$. When a joint of pipe is to be bent the material is put in position as demanded for its size, then the treadle is brought down by the pressure of a foot on the treadle; this at the same time draws down the top clamp firmly on to the material being worked on at the time. Then the brake wing is grasped at the handle and swung up and forward as the dotted lines show. There are other ways for bending pipes, such as with larger and longer brakes, but these are not at all common. The ways and the machines described will answer all reasonable purposes.

Having now fully described the forming and braking of the square pipes I will next describe the complete measurements of all different kinds of pipes and stacks commonly used.

IX.

THE PUTTING IN OF WALL PIPES.

The making, also the different ways of getting out, and the way of putting into the walls of buildings, square, oval and round pipes, may now be considered. It is the practice in many shops to make the square pipes double, while others never use any but the single pipes. The difference as to safety between the two varieties would at the first thought seemingly be in favor of the double pipes. In my opinion the single pipes are as safe as any double pipe can be made. This point will readily be seen if the single pipes are put into the walls in the manner I describe. First, the manner of putting in the double pipes. These are generally put up in sections. The total length of a stack being found as wanted, the first section is put into the wall, joined on to the shoe or starter in the cellar, as demanded for the stack. Then the top section is joined to the bottom section and secured to the same by a slip joint. This is about all that is done in regard to making this style of square pipe safe by most furnace men, that is, in relation to joining the various sections together. No other protection is made to prevent loss of heat or to provide against the heating of the woodwork where the outside pipe comes in contact with it. This applies to new houses in particular. The pipe is secured from falling from between or buckling out from the place it is to occupy by a strip of wood being nailed by the furnace man over the pipe, against the studding, at each side of the pipe. These strips hold the pipe in position until the lathers put on the wooden laths for the plaster. The mode just described is the usual one followed by most furnace men to put in the double square wall pipes. The way I would recommend to put in the single pipes is thus: If the stack comes up in a partition wall, line the studding and, in fact, any exposed surface of the woodwork near the pipe with 3$\frac{7}{8}$″ wide strips of tin. Then use iron instead of wooden laths. These laths are made in the shop. Make them of No. 26 black iron and cut them 2$\frac{3}{8}$ inches wide by 16 inches long, the usual distance that studding are placed from each other. From a sheet 24x



96 inches sixty of these laths can be made. The drawing of the lath shows how the laths are to be shaped. A is the upper and B is the lower

edge. When nailed to the studding the edges are turned one-fourth of an inch wide. It takes $5\frac{1}{2}$ of these laths to the running foot, nailed one-fourth inch apart. One-inch barrel nails are the best with which to fasten the laths, one nail at each end. Then in addition to the tin lining and iron laths, the single wall pipes should be wrapped with asbestos paper. Paper that weighs ten pounds to the square, and in some cases one pound to a square yard, is the kind most used for this purpose. The best paste to use to fasten the paper to the pipes is the kind used by paper-hangers or bill posters. I have found this the cleanest, neatest and cheapest way of obtaining the desired result, and I may add that it is the most lasting way to fasten this kind of paper to hot air pipes. Comparing these two kinds of pipes with one another as to the amount of work it requires to make each kind, I would say that there is more work in the shop on the double pipes, but they can be put into the building in less time than the single stacks. One pipe has only to be made of the single stacks in the shop, but then at the building where the stacks go there is the extra work of lining the studdings, etc., with tin, and also the putting on of the iron laths. This nailing on of the laths is always done by the furnace man. To sum up all the conditions, the single stacks cost a little less than the double stacks, and, in my opinion, are practically as safe as any kind of pipe can be made if put into a building in the manner described. The foregoing also applies to oval pipes in all the essential particulars. As to the material used to make the different kinds of pipes, in some shops coke tin is used, IC for the smaller sizes and IX for the larger pipes. The best and most satisfactory results are obtained by using IC and IX bright charcoal tin. This applies to all kinds of pipes, etc. For lining tin as common a grade may be used as can be obtained. I would recommend that all sizes of square and oval pipes up to 16 inches wide be made of IC tin and the larger sizes of IX tin. For round pipes IC may be used for all sizes up to 10 inches. For larger sizes, up to 15 or 16 inches, IX tin. For any larger sizes it will be well to use No. 26 or No. 24 galvanized iron. The custom in most shops in making round pipes is to let them lap or slip into each other one and a quarter inches, five joints to a section. The circumferential seams are lightly soldered. This way I regard at once the cheapest and also the common-sense way to fasten these pipes together. In fact, it is a stiffer and a more durable way to keep the pipes round than any other. The double seaming of the ends of the pipes I regard as a waste of time and money, although the practice is still persisted in in some shops. One very bad fault with this mode of fastening pipes is that when once double seamed together the joints cannot be taken apart without some trouble and waste of pipe, while if the joints are merely soldered together they can very readily be taken apart. Then the double-seamed joints are not nearly so stiff to resist any outside pressure as

the slip joint kind. The oval pipes are joined together in precisely the same manner as the round pipes. Square pipes, it is understood, are double seamed together into sections. The only slip joints are at the upper end of each section.

To get at the amount of tin that is required to make up a given quantity of pipes, such as square, oval or round pipes: First determine what size sheets of tin you are going to use for the same. I would venture the opinion that it is cheaper in the long run to use the larger sizes, such as 20x28 inches, than the 14x20 inches size, although the larger size costs a trifle more per box. This item is, in my opinion, far overbalanced by the greater amount of pipe produced, with the same amount of time and labor, than out of the smaller sheets. This item has a very material bearing on the first cost of the finished pipes in the shop work, and overbalances any consideration that may be urged in favor of the shorter joints. Still, strange as it may seem, in many shops it is still the practice to use the shorter joints. These facts, borne in mind as stated, will, in many cases, determine what size tin will be used.

The tables which will be given in Article X will show the full size to cut the sheets as to their girt. This has only to be multiplied by the length of the quantity of pipe desired and by the tables given for each item as to length and breadth of the various sizes of pipes. These, supplemented by the tables of lengths, any required amount of material that is necessary to make a given quantity of pipes will be readily found.

X.

TABLES OF PIPES.

The following tables will be found useful, where rapid, full and complete answers are desired to any questions covered by them. I will take, for instance, the lengths of the cellar pipes that are required for the furnace as described in Article VI. These various lengths as given are, for the 8″ pipe 20′ 2″, for the 9″, 19′ 6″, for the 10″ pipe 6′ 6″, and for the 12″ pipe, 21′ 6″ round pipe is wanted. To ascertain just how many joints of the various sizes of pipes, given above, it requires to make each amount as given, refer to the tables for lengths of the round pipes.

There are two tables for these pipes; one covers the lengths of the pipes made 14″ long, and the other for pipes each made 20″ in length. Allowance has been made for laps, and the tables also show what sizes the material is to be cut, laps for seams are allowed, also showing how many seams or locks the various sizes of pipes require, etc , etc. In fact, almost any question that may occur in practice coming within the province of these tables is fully met. If the 8″ pipes are made of 14″ lengths, it will require 18 joints and 12½″, or say 19 joints. If the joints are 20″ each, it will take 12 joints and 17″ of pipe, or nearly 13 joints. The number of joints for the other sizes of pipes is found in the same tables. The above does away with a great deal of figuring and calculations, which would have to be done in order to get the results, but which these tables show at a glance. The tables also give all data for square or rectangular pipes as ordinarily used, also for oval pipes, giving the areas, sizes, how the material is to be cut, and the lengths of sections, etc., etc.

TABLE OF LENGTHS FOR ROUND PIPES.

No. 1.

Material to be cut 20″ for the length of each joint; 5 joints to a section, 1¼″ lap.

1 joint	18¾″ long		6 joints	9′ 4½″	long
2 joints	3′ 1½″	"	7 "	10′ 11¼″	"
3 "	4′ 8½″	"	8 "	12′ 6″	"
4 "	6′ 3″	"	9 "	14′ ¾″	"
5 "	7′ 9¾″	"	10 "	15′ 7½″	"

The table for the lengths of oval pipes is the same as the above if the material is cut 20″ for the length of each joint and 1¼″ lap is allowed.

TABLE OF LENGTHS FOR ROUND PIPES.

No. 2.

Material to be cut 14″ for the length of each joint; 6 joints to a section, 1¼″ lap.

1 joint	12¾″ long		6 joints	6′ 4½″	long
2 joints	2′ 1½″	"	7 "	7′ 5¼″	"
3 "	3′ 2¼″	"	8 "	8′ 6″	"
4 "	4′ 3″	"	9 "	9′ 6¾″	"
5 "	5′ 3¾″	"	10 "	10′ 7½″	"

The table for the lengths of oval pipes is the same as the above, if the material is cut 14″ for length of each joint and 1¼″ lap is allowed.

TABLE FOR ROUND PIPE.

No. 3.

Sizes to cut material for joints 20″ long. One ½″ allowed for each lock, 20″x28″ tin.

Diameter.	Length.	Cut Pieces for Circumference. One Piece.		Locks.
5″	20″	16″		1
6″	"	19¼″		"
7″	"	22½″		"
8″	"	25⅝″		"
8¾″	"	27⅞″		"
		Two Pieces.		
		Large Piece.	Small Piece.	
9″	"	27″	2¼″	2
10″	"	27¾″	4⅜″	"
11″	"	"	7¾″	"
12″	"	"	10″	"
13″	"	"	14″	"
14″	"	"	17⅛″	"
15″	"	"	20⅛″	"
16″	"	"	23½″	"
17⅜″	"	"	27¾″	"

Cut the small end $\frac{3}{32}$″ smaller on one piece only for easy slip. Swage small end 1¼″ from end and 2″ from large end.

TABLE FOR ROUND PIPE.

No. 4.

Sizes to cut the material for joints 14″ long. One ½″ allowed for each lock, 14″x20″ tin.

Diameter.	Length.	Cut Pieces for Circumference. One Piece.		Locks.
5″	14″	16″		1
6″	"	19½″		"
		Two Pieces.		
		Large Piece.	Small Piece.	
7″	"	19¾″	3¼″	2
8″	"	"	6⅜″	"
9″	"	"	8½″	"
10″	"	"	12⅝″	"
11″	"	"	15¾″	"
12″	"	"	18⅞″	"

Cut the end of the smaller piece—which is intended for small end—$\frac{3}{32}$″ smaller than the above measurements.

TABLE OF SIZES AND AREAS OF OVAL PIPES.—DOUBLE PIPES.

No. 5.

Outside Pipes.	Inside Pipes.	Area in Sq. Inches of Inside Pipes.
3⅝″ x 11⅛″	3″ x 10¼″	29¼″
" " 12″	" " 11″	31½″
" " 14″	" " 13″	37½″
" " 16″	" " 15″	43½″

TABLE OF OUTSIDE OVAL PIPES.

No. 6.

Use 20″x28″ tin. One $\frac{1}{2}''$ allowed for each lock. Swage $1\frac{1}{4}''$ down for lap.

Sizes.	Length.	Girt.		Locks.
		Large Piece.	Small Piece.	
$3\frac{5}{8}''$ x $11\frac{1}{8}''$	20″	$26\frac{7}{8}''$	None.	1
" " 12″	"	$27\frac{3}{4}''$	$1\frac{3}{8}''$	2
" " 14″	"	"	$5\frac{3}{8}''$	"
" " 16″	"	"	$9\frac{3}{8}''$	"

TABLE OF INSIDE OVAL PIPES.

No. 7.

Use 20″x28″ tin. One $\frac{1}{2}''$ allowed for each lock. Swage $1\frac{1}{4}''$ down or lap.

Sizes.	Length.	Girt.		Locks.
		Large Piece.	Small Piece.	
3″ x $10\frac{1}{4}''$	20″	$24\frac{3}{8}''$	None.	1
" " 11″	"	$25\frac{7}{8}''$	"	"
" " 13″	"	$27\frac{3}{4}''$	$2\frac{1}{8}''$	2
" " 15″	"	"	$6\frac{1}{8}''$	"

TABLE OF OUTSIDE OVAL PIPES.

No. 8.

Use 14″x20″ tin. One $\frac{1}{2}''$ allowed for each lock. Swage $1\frac{1}{4}''$ down for lap

Sizes.	Length.	Girt.		Locks.
		Large Piece.	Small Piece.	
$3\frac{5}{8}''$ x $11\frac{1}{8}''$	14″	$19\frac{3}{4}''$	$7\frac{5}{8}''$	2
" " 12″	"	"	$9\frac{3}{8}''$	"
" " 14″	"	"	$13\frac{3}{8}''$	"
" " 16″	"	"	$17\frac{3}{8}''$	"

TABLE OF INSIDE OVAL PIPES.

No. 9.

Use 14″x20″ tin. One $\frac{1}{2}''$ allowed for each lock. Swage $1\frac{1}{4}''$ down for lap.

Sizes.	Length.	Girt.		Locks.
		Large Piece.	Small Piece.	
3″ x $10\frac{1}{4}''$	14″	$19\frac{3}{4}''$	$5\frac{1}{8}''$	2
" " 11″	"	"	$6\frac{5}{8}''$	"
" " 13″	"	"	$10\frac{5}{8}''$	"
" " 15″	"	"	$14\frac{5}{8}''$	"

TABLE OF SINGLE OVAL PIPES.

No. 10.

For hot air and ventilating pipes.

Sizes.	Area.
3½" x 8"	25 square inches nearly
3¾" x 9"	30¾ " "
" " 10"	34½ " "
" " 12"	42 " "
" " 14"	49½ " "
" " 16"	57 " "

TABLES OF SINGLE OVAL PIPES.

No. 11 A.

Use 14"x20" tin. One ½" allowed for each lock. 1¼" lap.

Sizes.	Length.	GIRT.		Locks.
		Large Piece.	Small Piece.	
3¾" x 7⅝"	14"	20"	None.	1
" " 9"	"	19¾"	3½"	2
" " 10"	"	"	5½"	"
" " 12"	"	"	9½"	"
" " 14"	"	"	13½"	"
" " 16"	"	"	17½"	"

No. 11 B.

If 20"x28" tin is used.

Sizes.	Length.	GIRT.		Locks.
		Large Piece.	Small Piece.	
3¾" x 8"	20"	20¾"	None.	1
" " 9"	"	22¾"	"	"
" " 10"	"	24¾"	"	"
" " 11⅝"	"	28"	"	"
" " 12"	"	27"	2¼"	2
" " 14"	"	27¾"	5½"	"
" " 16"	"	"	9½"	"

TABLE OF LENGTHS FOR SQUARE WALL PIPES.

No. 12.

Cut the tin 19⅞" for the length of each joint. ½" allowed to join the joints together.

No. of Joints.	5 Joints for a Long Section.
1 joint	19½" long
2 joints	3' 3" "
3 "	4' 10½" "
4 "	6' 6" "
5 " Less 2½" for slip.	7' 11" "
6 joints	9' 6½" "
7 "	11' 2" "
8 "	12' 9½" "
9 "	14' 5" "
10 "	16' ½" "

For double seamed round pipe the measures are the same as to length for the first five joints.

TABLE OF LENGTHS FOR SQUARE WALL PIPES.

No. 13.

Cut the tin 13⅞″ for the length of each joint. ½″ allowed to join the joints together.

No. of Joints.	6 Joints to a Long Section.
1 joint	13½″ long
2 joints	2′ 3″ "
3 "	3′ 4½″ "
4 "	4′ 6″ "
5 "	5′ 7½″ "
6 " Less 2½″ for slip.	6′ 6½″ "
7 joints	7′ 8″ "
8 "	8′ 9½″ "
9 "	9′ 11″ "
10 "	11′ ½″ "

For double seamed round pipes the measures are the same as to length for the first six joints.

TABLE OF SIZES OF SQUARE PIPES THAT ARE COMMONLY USED.

No. 14 A.

Double Pipes.

Outside.	Inside.	Area in Square Inches.
3½″ x 10″	3″ x 9½″	28½ sq. in.
" " 11″	" " 10½″	31½ "
" " 12″	" " 11½″	3[illegible]½ "
" " 13″	" " 12½″	37½ "
" " 14″	" " 13½″	40½ "
" " 15″	" " 14½″	43½ "
" " 16″	" " 15½″	46½ "

No. 14 B.

Single Pipes.

	Area in Square Inches.
3¾″ x 6″	22½ sq. in. nearly
" " 7″	26¼ "
" " 8″	30 "
" " 9″	33¾ "
" " 10″	37½ "
" " 11″	41¼ "
" " 12″	45 "
" " 13″	48¾ "
" " 14″	[illegible]2½ "
" " 15″	56¼ "
" " 15¾″	58 13-16 sq. in.

Vent Pipes.
No. 14 C.

Sizes.	Area.
3″ x 5″	15 sq. in.
" " 6″	18 "
" " 7″	21 "
" " 8″	24 "
" " 9″	27 "
" " 10″	30 "
4″ x 6″	24 "
" " 7″	28 "
" " 8″	32 "
" " 9″	36 "
" " 10″	40 "
" " 12″	48 "
" " 14″	56 "
" " 15″	60 "
" " 16″	64 "

TABLES OF SQUARE OR RECTANGULAR PIPES.—OUTSIDE PIPES.
No. 15 A.

Use 14″x20″ tin. One ½″ allowed for each lock.

Sizes.	Length.	Girt.		Locks.
		Large Piece.	Small Piece.	
3½″ x 10″	13⅞″	19¾″	8¼″	2
" " 11″	"	"	10¼″	"
" " 12″	"	"	12¼″	"
" " 13″	"	"	14¼″	"
" " 14″	"	"	16¼″	"
" " 15″	"	"	18¼″	"
" " 16″	"	"	20″	"

INSIDE SQUARE PIPES.
No. 15 B.

Sizes.	Length.	Girt.		Locks.
		Large Piece.	Small Piece.	
3″ x 9½″	13⅞″	19¾″	6¼″	2
" " 10½″	"	"	8¼″	"
" " 11½″	"	"	10¼″	"
" " 12½″	"	"	12¼″	"
" " 13½″	"	"	14¼″	"
" " 14½″	"	"	16¼″	"
" " 15½″	"	"	18¼″	"

TABLES OF SQUARE OR RECTANGULAR PIPES.—OUTSIDE PIPES.
No. 16 A.

Use 20″x28″ tin. One ½″ allowed for each lock.

Sizes.	Lengths.	Girt.		Locks.
		Large Piece.	Small Piece.	
3½″ x 10″	19⅞″	28″	None.	1
" " 11″	"	27¾″	2¾″	2
" " 12″	"	"	4¾″	"
" " 13″	"	"	6¾″	"
" " 14″	"	"	8¾″	"
" " 15″	"	"	10¾″	"
" " 16″	"	"	12¾″	"

INSIDE SQUARE PIPES.

No. 16 B.

Sizes.	Lengths.	Girt. Large Piece.	Girt. Small Piece.	Locks.
3" x 9½"	19⅞"	25"	None	1
" " 10½"	"	27"	"	"
" " 11½"	"	27¾"	2¼"	2
" " 12½"	"	"	4¼"	"
" " 13½"	"	"	6¼"	"
" " 14½"	"	"	8¼"	"
" " 15½"	"	"	10¼"	"

TABLE OF SINGLE SQUARE OR RECTANGULAR PIPES.

No. 17.

Use 20"x28" tin. One ½" allowed for each lock. One ½" allowed to join the ends together.

Sizes.	Length.	Girt. Large Piece.	Girt. Small Piece.	Locks.
3¾" x 6"	19⅞"	20"	None.	1
" " 7"	"	22"	"	"
" " 8"	"	24"	"	"
" " 9"	"	26"	"	"
" " 10"	"	28"	"	"
" " 11"	"	27¾"	2¾"	2
" " 12"	"	"	4¾"	"
" " 13"	"	"	6¾"	"
" " 14"	"	"	8¾"	"
" " 15"	"	"	10¾"	"
" " 15¾"	"	"	12½"	"

TABLE OF SINGLE SQUARE OR RECTANGULAR PIPES.

No. 18.

Use 14"x20" tin. One ½" allowed for each lock. One ½" allowed to join the ends together.

Sizes.	Length.	Girt. Large Piece.	Girt. Small Piece.	Locks.
3¾" x 6"	13⅞"	20"	None.	1
" " 7"	"	19¾"	2¾"	2
" " 8"	"	"	4¾"	"
" " 9"	"	"	6¾"	"
" " 10"	"	"	8¾"	"
" " 11"	"	"	10¾"	"
" " 12"	"	"	12¾"	"
" " 13"	"	"	14¾"	"
" " 14"	"	"	16¾"	"
" " 15"	"	"	18¾"	"
" " 15⅝"	"	19⅞"	19⅞"	"

The foregoing tables may be modified in so far as in some shops the slip that I have allowed on the various pipes requiring slip joints, are sometimes made larger, and in other cases, smaller to meet those conditions. The differences must be allowed for in calculations. And also the standard

for the round pipes is not strictly adhered to in some shops, the custom being to rather making pipes a little under, than full sized. It will be well to bear all these points in mind when using the tables, if any deviations are made from the figures and measures as the tables give. The Figures 22 to 29 show different kinds of slip and double-seamed joints, end views of both square and oval wall pipes; braces and cleats are also shown. Figures 22 and 23 give end views of square and oval pipes. In Fig. 22 the

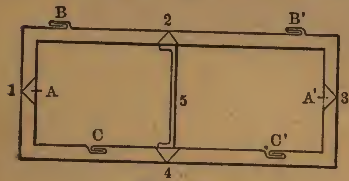


Fig. 22

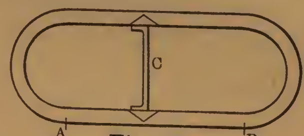


Fig. 23

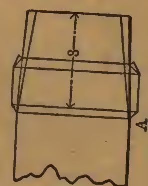


Fig. 24

relative positions of the outside and inside pipes of a square stack are shown; if the same are braced as the numerals, 1 to 4 give, 5 is the brace that is placed inside of the smaller pipe. The up and down seams of both pipes are also shown at B, B′, and at C, C′. In cases where a joint is made of two equal pieces the seams are frequently placed at the ends at A, A′. The oval pipe, Fig. 23, shows two braces between the outside and inside, only. More than these are rarely ever used between two joints. A and B show where the seams in oval pipes are generally placed; C is the inside brace. Fig. 24 gives the slip joint of a single square pipe, the four corners are cut down 3″ and bent over, lapped and tacked at the top. A $1\frac{1}{4}'$ strip is soldered on to each end and side as shown in the figure at A, to hold the next joint firmly in place. Fig. 25 shows another kind of slip joint. The

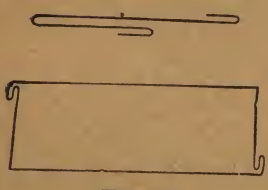


Fig. 25

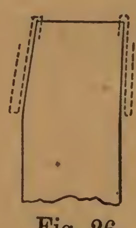


Fig. 26

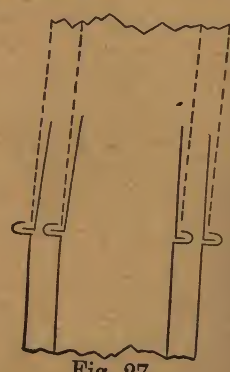


Fig. 27

pipe is bent at two opposite corners, as Fig. 25 shows, and a strip of tin bent as shown in Fig. 25 is placed in the joint in the manner as Fig.

26 shows. Fig. 27 gives a style of slip joint that is used in some shops. This shape I regard as a very poor one to use, by reason that it is not as strong as the foregoing kind described, and its greater cost to make

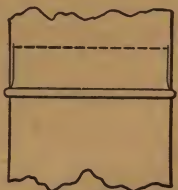


Fig. 28

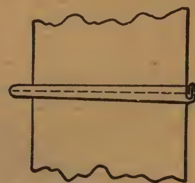


Fig. 29

the same. Fig. 28 gives the common style of slip joint, used for round and oval pipes. Fig. 29 shows the double-seamed joint used on round pipes.

XI.

PIPE MAKING TOOLS.

It may be well to give, in connection with the tables and other data of the different kinds of pipes, a brief description of some of the most used, and to obtain the best results, the most necessary tools, used in making the different kinds of hot air pipes. In putting the round pipes together, the practice, in some shops, is to cut the joints for the round pipes without any taper whatever; that is, both ends are made exactly alike as to size; then, in order that one end will go into another, the end intended to be the smaller one, is run through a crimping machine. This operation naturally makes one end smaller and easy fitting, but with this drawback, that crimping the end of each joint leaves the corrugated and rough surface inside of the pipe, when the main point to be attained should be absolute smoothness and an even surface in the interior of the pipes. Any rough or uneven projections hinder and retard the steady and smooth flow of the air through the pipes. The reasons given above are ample to condemn this practice as unsuitable. It should never be tolerated in shops where it is the aim to do good work. The right way is to cut the joints tapering, say one-eighth inch smaller on the small end; this allows for a good, close fit. Then, when the pipes are put together, the surfaces of both ends will lay up snug and tight, in fact, make a job as it should be, and not a botch.

When a lot of pipe is prepared and all the foregoing directions have been complied with, soldering the joints into sections is the next operation in order. If the joints fit snug and well, the circumferential seams

may be soldered lightly. Do not merely tack them, but be sure that the seams are soldered all around. Do not leave an opening here and there, but finish the work well. Fig. 31 shows a pipe soldering trough made out of

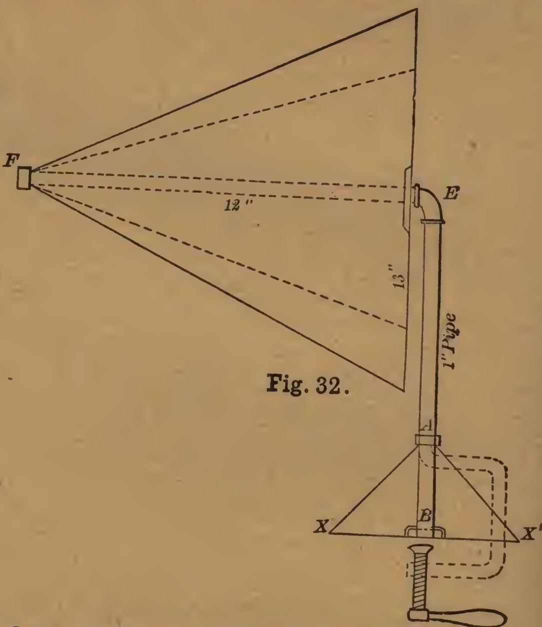


Fig. 32.

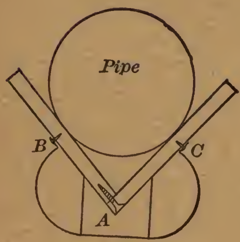


Fig. 31.

two boards for the sides, and for the standards small blocks, as A shows. Place at each end, or near the ends, strips of band iron as B, A to C give. The shape as given for the bands allows for the easy handling of the trough, and are just enough rocker-shaped to tip over to either side, without any great waste of force. The size of the sides may be 8″ wide. As to the length, this is as long as a section of pipe requires. Another style of pipe soldering machine is shown in Fig. 32. Two of these conical pipe holders are used to hold the sections together, while they are being soldered. There are three different ways shown to fasten the holders to the bench. One is accomplished by means of a cone, as A, X to X′ shows. This part is filled with sand or lead, so as to make it heavy enough to hold the holder firmly to the bench, and also, at the same time, to hold the pipe firmly. Another way is to take from A to B and set this into the bench as you would any other tool. The best way to make the part, to fasten the holders to the bench, is the way shown by the dotted lines and the clamp screws underneath the bench. The holding part attended to, continue the standard to any desirable height, up to where the turn at E shows. The holding parts are made of 1″ steam pipe, as is shown by the drawing. Make the length

of the piece of pipe, through the cone, one inch longer than the cone is to be when finished. As is shown, a nut is screwed on the end to secure the cone permanently in its proper position. The cone itself may be made of No. 20 gauge iron with a bottom in the large end of the same gauge of iron. A strengthening plate may be put in the center as shown. When complete the cone may be slipped onto the horizontal bar, up to the ridge of the elbow, and on the other end secured from coming off from the bar by the nut shown at F. The general dimensions of the holders are given by figures. It is understood that two of these pipe holders are to be made. The cones are to have enough play to revolve freely on the horizontal bars of the holders. There are other kinds of pipe soldering machines in use, some made in very elaborate style, but the kind I have described will answer all practical purposes, and have the recommendations in their favor that they are cheap, durable and easily made.

For putting together square pipes into sections, a bar of iron 1″ or $1\frac{1}{4}$″ thick, by $3\frac{1}{2}$″ wide will be found the most convenient shape to use as a stake; this may be secured to the bench in the manner Fig. 33 shows. An arrangement to hold up the ends of the sections, so that the workman can conveniently and with ease join the joints on to the sections, and that without the additional assistance of a helper, is also shown in Fig. 33. To rig up this arrangement, take a bar of $\frac{3}{4}$″ rod, and fasten the same any convenient distance above the stake you are working upon. Make the pulley

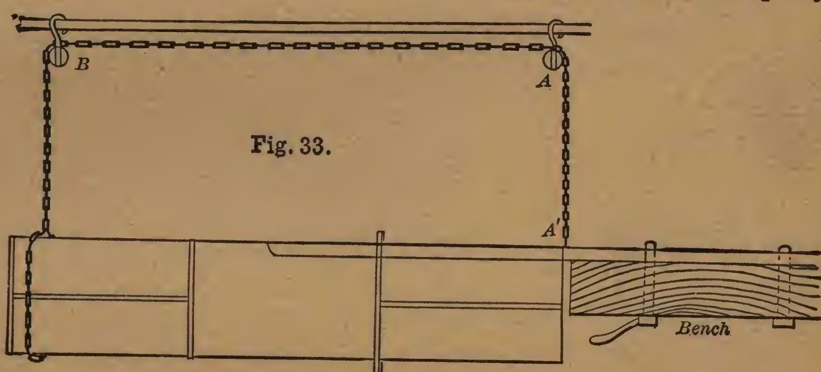


Fig. 33.

fixed in the position as shown, while the pulley B may be hung in such a manner that the same can be shifted back and forth on the $\frac{3}{4}$″ bar as may be desirable to suit the work at any time. A small chain, or even a cord, can then be adjusted to the end of the pipe farthest from the workman, and so arranged over the pulleys as shown. The end D can then be fastened to the bench in the manner which best suits the workman. It will be seen at a glance that this device answers the purpose in every re-

spect. A very handy arrangement is also shown, in Fig. 34, in a mallet with a strip of steel fastened to the same by two bolts or rivets. The piece so fixed to the mallet answers all the purposes of a casing knife, pinning hammer, etc., sometimes used while putting together square pipes. The other end of the mallet is used to hammer down the seams of the pipe. The figure gives a side and end view of a right-handed tool. It would be

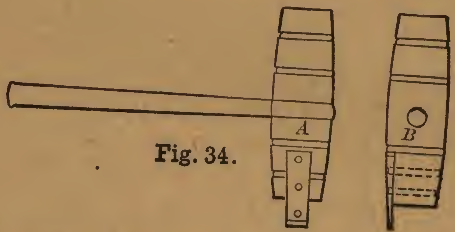


Fig. 34.

well to select a fine-grained hardwood mallet for the purpose indicated in the above, and also not to choose too large a one for this purpose. In my opinion a man can do more and better work with a properly proportioned tool than with one that is too large, clumsy and unwieldy.

XII.

WALL PIPE STARTERS.

In this article I will give a description of some of the different styles and kinds of starters that are mostly used by furnace men throughout the country.. These parts of furnace pipes are also named in some shops shoes or boots, but in my opinion the name "starter" is the more proper one, as it more clearly defines the position at which these parts are used, namely, the starting points in the cellar for the stacks or wall pipes to which they are connected. Before I enter into a detailed description of the various shapes in particular, I would like to remind the student that the following very important points should, and, to insure the best results, must be borne in mind and made use of in the practical work, when work of this kind is gotten out and put up. One of the first considerations is the purpose for which a starter really is made when designing it to fit into a given place or into a certain location. The positions into which the furnace man often has to make his work fit, necessitate angles, crooks and turns that, if made too abrupt, will almost, if not wholly, retard the flow of the air through the pipes. The purpose and intent of a well-designed starter is to provide a suitable connection and to insure an easy and smooth flow for the hot air from the round pipes of the furnace, into the square or oval wall pipes in

the partition walls of the building. How many jobs are done without the slightest regard being given to this most important point, when the starters are made and put into buildings, every furnace man of any experience could only too well tell, if he felt so disposed. The main point is: Have as few angles as possible; get as direct and smooth an inlet as possible; if any turns or angles are to be made, make them rounding, and make them with two or more joints, rather than with only one single angle. Then do good work on these parts. If it is intended that the seams are to be double seamed, have them so. Do not botch the work, but make them solid, and not as some do, that is, if a seam does not just come right, it is pounded down anyhow, and if, when the tinker is done battering the seam down, the locks are not caught but stand wide open, recourse is had to the soldering of the seams. This is poor work, and I may say it takes more time to do it than if a good, careful and neat job had been done in the first place. A specimen of a poorly designed starter is shown in Fig. 35. A shows a straight piece of stack let down far

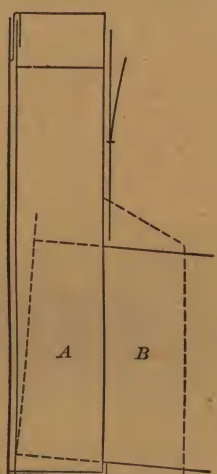


Fig. 35

Fig. 36

enough through or below the level of the cellar ceiling so as to admit the entrance of a round pipe into it without interfering with the woodwork above. As will be seen no collar is put onto the square pipe, but instead a hole of the size of the pipe that is to connect with the stack is cut into the same, and the pipe is merely pushed into this opening thus provided. This way of doing this part is about the poorest and cheapest way it can possibly be done. It frequently happens that the pipe is pushed into the stack too far when the pipes are being put up by careless workmen. This is shown by dotted lines in A. It is plainly to be seen that if a case happens as

shown by Fig. 35, hardly any air goes up into the wall pipe. This little illustration may explain to some furnace men why pipes frequently do not send up warm air as they ought to, and which they perhaps would if they had been put in properly in the first place. The remedy for this is: Put collars into every stack, so as to receive the hot air pipes in the cellar, and no trouble will occur from this reason. I may perhaps on this occasion show up a practice that tricky furnace men are guilty of in the putting up of stack work in some instances. It sometimes happens that the contract for the putting in of the stack work is let to one firm, while another firm secures the contract to put in the heater or furnace. Now, I have met with cases where the worthies who were putting the wall pipes into the buildings not alone put in the worst style of starters—those of the kind shown by Fig. 35, A—but they did not even cut any holes into the stacks at all, at the bottom ends of the various stacks, leaving this to be done by the unfortunate furnace man who had to make the connections with the furnace to the stacks. Any one who has ever had to do the cutting out of these openings into double stacks after the stacks were put into their positions, and as sometimes it may have happened that not enough clearance had been allowed to properly fit in the required size of pipe, knows what a mean, disagreeable job it is to do work of this kind. The foregoing hints will show what kind of work not to do. What to do is—use better shapes than A of Fig. 35 gives for this purpose; always put in connecting collars into the starters and allow enough clearance for the proper fitting of the connecting pipes. A somewhat better shape than A of Fig. 35 is shown by the dotted lines of B, of the same figure. This modification of the starter is far better to allow an easier flow of the entering volume of air, and, if a collar is put to it, it makes a good job in some cases. A favorite shape with many furnace men, for a starter, is shown by Fig. 36. A side view is given by the solid lines of a 10″x3½″ starter, with a 9″ collar for the round pipe in the cellar to enter the same. All the dimensions are given in figures. This starter is made out of a sheet of 20″x28″ tin for the back, sides and part of the front. For larger sizes, that is, for wider starters, such as for instance 3¾″x12″ or 14″, the sides may be made somewhat narrower, as shown by the dotted lines. The foregoing starters as described are made so that the pipes or angles enter at the side of the starters, and require no extra elbows to guide the flow of air upward. These starters are for positions where the stacks have a straight upward course. Another style, also intended for stacks that run straight up, but have an elbow or turn attached at the bottom, is shown by A, Fig. 37. This starter is made flat and square at the bottom, large enough to admit the size collar it is intended to use for the same, while the top end is made according to the size required for the stack it is intended to fit into. The sides may either be made straight, as A

shows, or they may be made with a curve, as B shows. Another shape is shown by C, or the dotted lines of Fig. 37. This shape is often used where

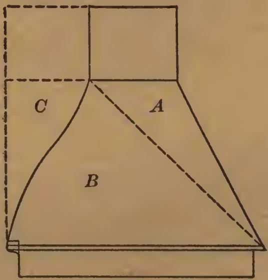


Fig. 37

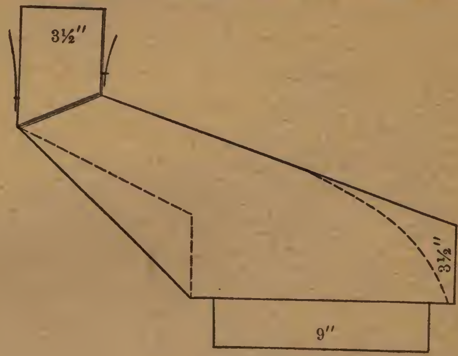


Fig. 38

the circumstances demand a form of this kind. In cases where a partition comes above a timber or a cellar wall, a style as in Fig. 38 is used in many shops. A somewhat nicer shape is shown by the dotted lines. Both kinds

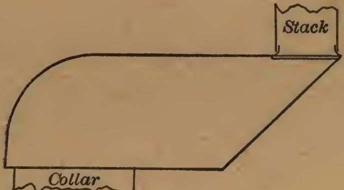


Fig. 39

Fig. 40

answer the purpose fully. The end that enters the stack may be made to fit either style, square or oval, as demanded. Fig. 39 gives a side view of a rather clumsy-looking, box-like affair. The two collars are cleated on to the bottom and top. This kind is not often used, but may be made available in some peculiar cases. Fig. 40 shows a favorite starter with most

furnace men and this with good reason. Considering the shape as the side view shows, it will be seen at a glance how well adapted this shape is to fulfill the main requirements demanded for a perfect starter. First, the easy flow of the warm air—notice how smooth and unobstructed the inside upper surface is. Then there are absolutely no abrupt or sudden turns and angles. The shape of this starter admits of its laying snug up against the wall. There is no elbow required to connect the starter with the cellar pipe. In short, I would recommend this style to be used wherever it is necessary to make a bend over a wall to connect onto a stack. The starters as described in the foregoing may be changed so as to suit the positions where they are to be put into, as to the measurements of width, length, sizes of collars as inlets or outlets of the same; in brief, the forms and measurements may be changed as the occasion may demand.

Fig. 41 shows a convenient style of a starter sometimes made use of where economy of space has to be considered. If a cellar pipe is to be run close up to a ceiling so as to obtain all the rise that can possibly be obtained in a given place, a joint of pipe may be used by putting a tee on to the same as Fig. 41 gives an end view of. The collar or tee may be rectangular or oval, as demanded. The farther end may be closed up with a removable cap, as it may sometimes be desired to clean out the pipe. The size of this pipe is to be as the conditions demand where it is to be used.

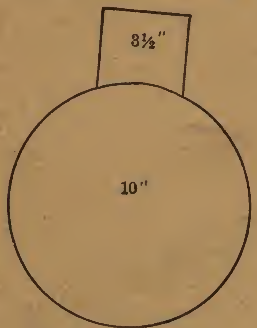


Fig. 41

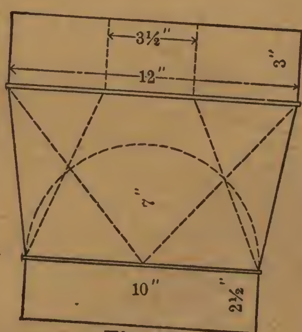


Fig. 42

A style of starters lately made by some first-class furnace houses is shown by Figs. 42, 43 and 44. These starters are rather of a fancy kind of design and if well made are very handsome looking. They have no sharp and sudden turns or corners; can be made as quickly and cheaply as any other kind of equal merit and are good goods to talk up, when bidding on work and comparing them with other styles of starters. The chief reason why the last mentioned styles have not come into more general use seems to be that most furnace men are not inclined to study up the pat-

terns that are required for the proper laying out of these shapes; some have not the time, etc. In the following I will give a complete exposition how to lay out the patterns as required for these starters so that it will be an easy matter for any one to lay them out in short order. To lay out the shape as given by Fig. 36, take a sheet of 20″x28″ tin; square the same to

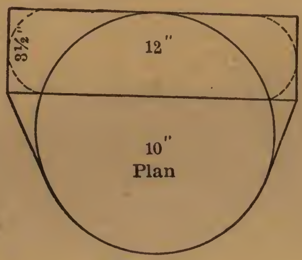


Fig. 43

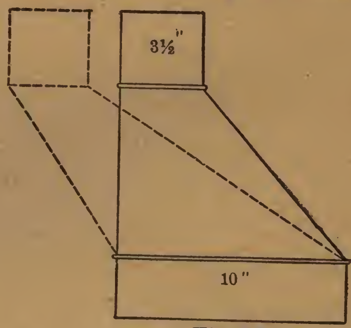


Fig. 44

the size of $19\frac{3}{4}$″x$27\frac{3}{4}$″. Mark off the space A, B, C and D, as Fig. 45 shows, equal distance from each end of the sheet. A to B goes the $19\frac{3}{4}$″ way of the sheet. Then mark off the distances required for the two ends of the starter as the $3\frac{1}{2}$″ spaces show. Draw lines E to F and E′ to F′. Then for the projecting parts mark off whatever space it is intended to make the same. In this pattern I have made this distance $3\frac{1}{2}$″ which is the same as demanded by Fig. 36, the Fig. 45 being the pattern for Fig. 36. The two parts from X to E and from E′ to X′ are to be made equal to the 10″ back, and consequently must each be cut $5\frac{1}{4}$″ long, the extra $\frac{1}{2}$″ being for the allowance for the lock or seam in the center. The distances from E to K and from E′ to K′ are governed by the amount of material which is left after the projecting parts are laid out. At the two ends, at X and at X′ locks are turned for the seam in front. The other edges shown by the double lines are all to be turned off one way at right angles from the sheet, $\frac{1}{8}$″ in width. The sheet is now ready to be shaped as demanded by the Figure 36. When doing this turning, be careful that all the $\frac{1}{8}$″ edges are on the outside so that the other parts that are to be double seamed onto the same will lock. The measure for the length that the piece is to be cut that goes on to the projecting part and also onto the bottom, is found by the distance from K to S to F and to B. For the width of same, take 10″ and $\frac{1}{2}$″ as the allowance for the two side double seams. Also add a $\frac{1}{2}$″ for both top and bottom ends. Turn the locks as required; bend this part to shape, and double-seam it on to the other part as demanded. The hole for the required size collars may now be cut. The collers are generally made to cleat on to the starters. In some shops they have a way of doing this work by turning a

deep swage or bead outward on the collar, at about a distance of $\frac{3}{8}''$ from the edge, then when the collar is put into the starter up to this bead the $\frac{3}{8}''$ part, which projects into the starter, is bent over, thus making the collar

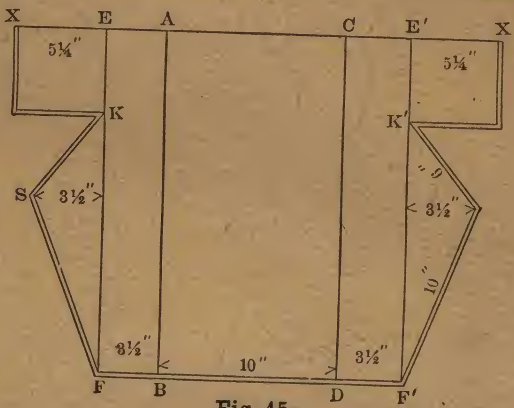


Fig. 45

firm and fast to the body of the starter. Another way is to rivet a strip of tin on to the outside of the collar after a $\frac{1}{4}''$ edge has been turned on to the end of the collar that is to set up against the starter. The collar projects $\frac{1}{2}''$ out and is notched so as to be easily bent over onto the inside of the starter when the collar is put onto the same. This last operation is commonly called cleating the collar to the starter. A mode that is to be avoided and which I regard as a very poor way to do this operation, is sometimes done by indifferent workmen, and consists in their simply notching a collar all around on the end intended to be fastened to the starter, then bending out every other part between the notches at right angles from the collar; the remaining parts that have not been bent are pushed in to the starter and bent over on the inside, while those parts that have not been bent outward beforehand are intended to keep the collar from slipping any farther into the starter. Taken altogether this method of doing the operation is not what it should be, as the tin of which the collar is made is never strong enough to withstand even a very slight jar or the strain which the weight of the pipe imposes on to the collar when the same is connected on to the starter. This cause alone in a short time draws the collar from its fastening. Then a tight fit can never be made with this method. My advice is: Do not use this method under any consideration. It is understood that each starter is to have strips of tin riveted to some of its sides or ends for fasteners, each as are shown on Figs. 35, 36 or 38. These strips are to be long enough so that they can be nailed to the surrounding woodwork where the starters go, so as to secure the starters

permanently in place. At the upper end of each starter slip-joints are to be put, such as the figures 35 or 36 show. A full description of the various slips as generally used has been given in Article X, from which the workman has his choice as to whatever kind he cares to use.

To lay out the patterns for the starters such as Fig. 43 gives an end view of by the dotted lines and a side view by the solid lines, the first step to take is to draw the plan of the round end as in the Fig. 46, part A. Then draw one-half of the rectangular end in the correct position it is intended it should be when the starter is finished. This is also shown in A of Fig. 46. One-half of the rectangular and also of the round end is shown. This is all that is necessary to lay out the required patterns. The semi-circle from 1 to 1′ is the bottom end, and A, B, C and D is the rectangular end. Then draw the end elevation as part B of Fig. 46 from to 1 to 1′ and 1″ to 1′ ″ give, also the side elevation as 1 to 1′ and C to C″ give for this view. The foregoing is all plainly shown in Fig. 46. I

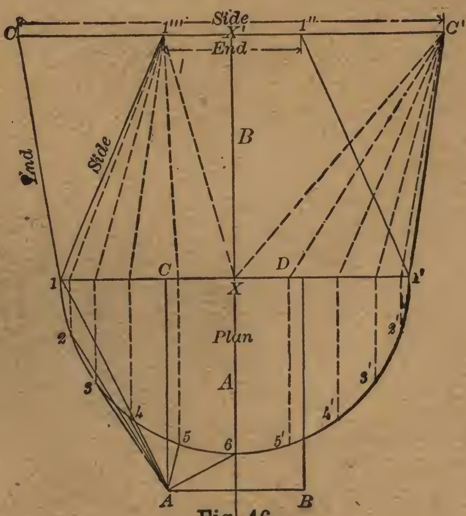


Fig. 46

will call this the outlines for the desired shape. It is not necessary to draw the two ends or collars, as they are not needed to lay out this shape. The main difficulty with most workmen is to develop the required pattern for a rectangular to the round shape. To many, this may seem a very formidable problem, but in reality it is a far more easy undertaking than it appears at the first glance. In fact, it is nothing more than a simple problem to be solved by triangulation and is done in the following manner: Divide one-half of the semi-circle into any number of equal parts.

In this case I have divided it into five parts as the numerals 1 to 6 show. Next draw a right angle as the lines A to B and A to C of Fig. 47 show. Make the line A to C or the point C equal in length to the distance X to X′ of the height of B of Fig. 46, or in other words, equal to the real height that this part will have vertically when done. Point C, and the distance also, is thus established between the same and A of Fig. 47. Take the distance from A of Fig. 46 and mark off the same distance on line A to B of Fig. 47, thus establishing the point 1 of this line. Connect point C of line A to C with point 1 of line A to B by the line C to 1. This line is of the same length as the real length of the line from X to point C′ of B, of Fig. 46. Next take the distance from point A of part A of Fig. 46, to the point 2 of the semi-circle of the same figure and mark off an equal distance on line A to B of Fig. 47. This is shown by point 2 on the same line. Connect the point 2 with the point or apex B by the line 2 to C. The distances from point A of Fig. 46, to the remaining points on the semi-circle from 3, 4, 5 to 6 are to be transferred in precisely the same manner as the foregoing distances have been transferred. This is all shown plainly in Fig. 47, on the line A to B, or base line. The connecting lines to the points from 1 to 6 are also fully shown and drawn out, and also their respective numbers marked at the points where they are connected with line A to B of Fig. 47. This is all that is needed for the preliminary drawing

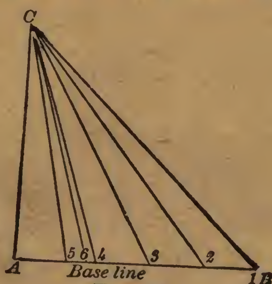


Fig. 47

to get the data necessary to lay out the pattern wanted. It would, perhaps, at this stage be well to caution the student that it is imperatively necessary that all the foregoing steps be done correctly and exactly, as well as the following, to assure a correct pattern when the drawing is finished. Slipshod or careless work wont do at all in operations of this kind.

To develop the pattern, draw line A to B of Fig. 48, equal in length, to the line C to C′ of Fig. 46. This line is equal in length to the length the side of the rectangular end of the part B of Fig. 46. Next draw the line C D from point C to D at right angles to line A to B of Fig. 48. The point C is equal distance from both points A or B, or the center of

line A to B of Fig. 48. The line C to D is to be equal in length to the line 1 to 1″ of part B, of Fig. 46. This line shows the true length of the side of the pattern and must have the true length in the same as it has from point C to point D of Fig. 48. Next connect the point D with B by a line equal in length to line C to 1 of Fig. 47; do the same with points D and A of Fig. 48. This develops the triangular part from A to B and D

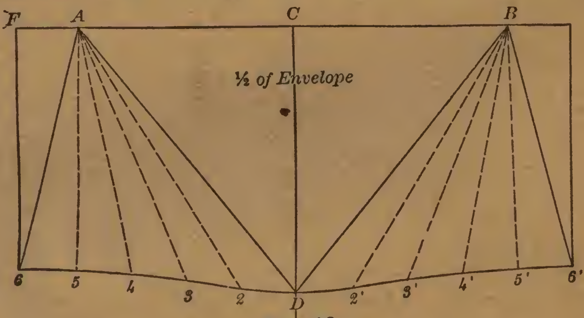


Fig. 48

of Fig. 48, and is that part of one of the sides which is a flat surface or a flat plane. Now take the distance of one of the spaces as found on the semi-circle of Fig. 46, and mark off an arc equal in distance from the point D of Fig. 48, as is shown at 2 of Fig. 48. Then take the distance of the length of line C to 2 of Fig. 47, and from point A of Fig. 48 to where this distance intersects the arc as developed from point D, the point 2 is established. Do the same on the other side from B to point 2′. The distance to points 3 and 3′ on either side from points 2 and 2′ is the same as from D to 2 or 2′ of Fig. 48. Then the distance from A to 3 is the same as from point C to 3 of Fig. 47. The same is the case with the distance from point B to 3′ of Fig. 48. A similar operation is to be done in regard to establishing the positions of all the other points from 3 to 6 and from 3′ to 6′ of Fig. 48. The length and distances from the various lines connecting points A and B of Fig. 48 to the respective points from 3 to 6 and 3′ to 6′ of Fig. 48, are all plainly shown by Fig. 47, and are to be drawn in the same manner as the preceding lines.

The space contained between 1‴, X′ and X of Fig. 46 is to be drawn into its proper position in Fig. 48. First take the distance from X to X″ of Fig. 46; set the dividers at point 6 of Fig. 48, and draw the arc which will cut the point F; then take the distance from X′ to 1‴ of Fig. 46. Set the dividers at A of Fig. 48 and cut the arc as found, where the last found distance or length intersects the arc the point F of Fig. 48 is established. Connect points A, F and 6 by lines A to F and F to 6; do the same at the other end of the pattern. This completes one-half of the en-

tire pattern. Connect the points D to 6 and D to 6′ by a free hand line. As both sides of the shapes demanded for this starter are alike, the pattern as developed has only to be duplicated and the entire pattern is obtained. All locks and double seams are to be allowed for, extra, as the pattern as developed does not include this item. If all the lines are drawn on to the pattern as the Fig. 48 gives and when the same is formed to shape as demanded, the lines will appear on the end as given by the dotted lines of part B of Fig. 46, from 1 to X to 1‴, and on the side they will appear as the lines from X to 1′ and C′ give.

The development of the pattern for a shape as Fig. 43 as plan and 44 as elevation call for, is done in a somewhat similar manner to the foregoing. The only difference consists in the modification and the adaptation of the principles involved and the mode of developing the desired patterns to the altered shapes presented. The first step is to draw the plan of the top and bottom end of the desired shape as Fig. 49 shows. Divide the semi-

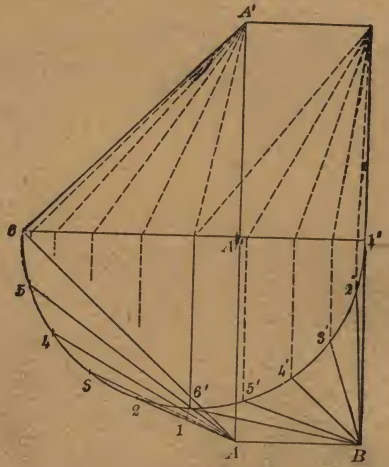


Fig. 49

circle into two sets of equal parts as shown. From point A connect these points as shown for one set as from 1 to 6. Do the same for the set numbers two as from B to 1′ to 6′. Then construct two sets of triangles as Fig. 50 for set number one and Fig. 51 for set number two give. Make the distance from A′ to X of Fig. 50 and the distance from B′ to X′ of Fig. 51 equal to the vertical height, as from A′ to A″ of the Fig. 49. The base lines from A to points 1 to 6 of Fig. 49 are the distances on line X to 6 of Fig. 50, and are the set of lines numbered 1. Point A as connected by the lines as shown with the points 1 to 6 of Fig. 50, gives the lengths of the distances that are used to develop the front part of the pattern of this part of the starter. The distances from the point B to the points 6′ to 1′ of Fig.

49, are the distances from point X′ to 1 of Fig. 51, and are the lengths of the base lines for the respective numbers to the point X′ of Fig. 51. This set of connected lines is the set number two, and are the lengths used to

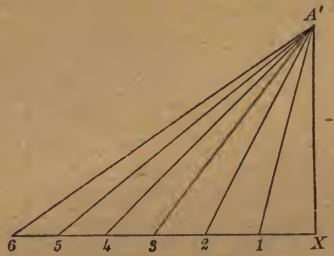


Fig. 50 No. 1

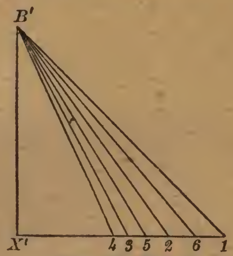
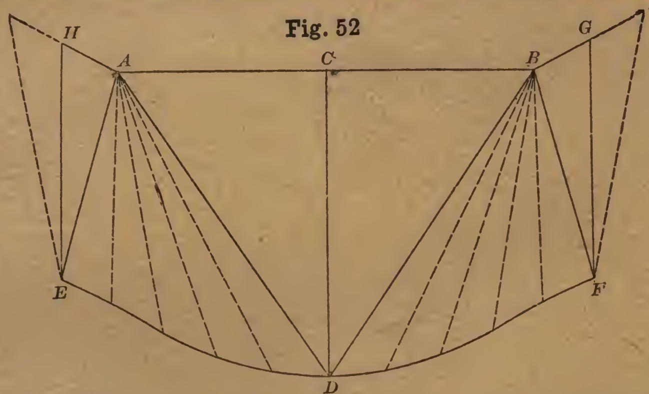


Fig. 51 No. 2

develop the back part of the pattern for this starter. After all the data has been obtained that is necessary to develop the required patterns, in the

Fig. 52



manner described, proceed to lay out the front part and also the back part in the same general way that the pattern Fig. 48 has been done. To repeat

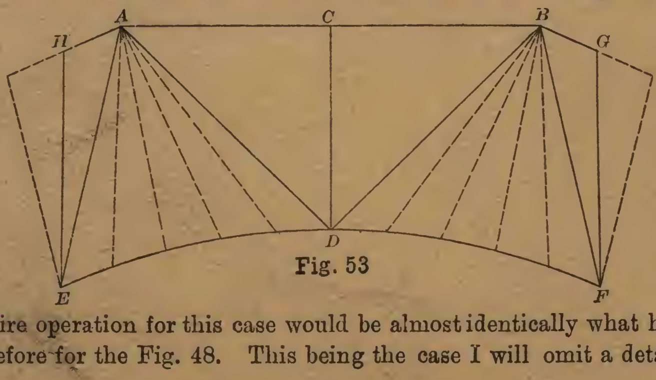


Fig. 53

the entire operation for this case would be almost identically what has been done before for the Fig. 48. This being the case I will omit a detailed de-

scription for these parts. The dotted lines that are added to the two figures of the front Fig. 52 and also the back Fig. 53, are added to the patterns so that if the workman decides to place the seams at the corners either at the front or back, instead of at the center of the ends, as the solid lines H to E and G to F give, he can do so. He must not forget to leave off the parts on the smaller side, or on the side on which he places the seams, while leaving the entire parts on the larger piece. Allow for all locks and seams, as the pattern only gives the actual surface necessary for the development of the patterns or envelopes of the shapes demanded.

XIII.

REGISTER BOXES.

The floor outlets, or register boxes, as shown in this article, are the kind used by furnace men generally. Fig. 54 is the common first floor single register box, used where a shallow shape is the most suitable one to answer the purpose. This style of box is generally made from $4\frac{1}{2}''$ to $5''$ deep, with a $\frac{1}{2}''$ flange to rest on, turned outward from the box either on the floor or into the recess of the register border. The practice of many furnace men is to use a single box only for the registers, not even using a border for the same, but setting the tin box into a suitable sized opening cut in the floor. The surrounding wood-work is lined with tin, as a matter of course, to secure safety from over-heating. This is the cheap way

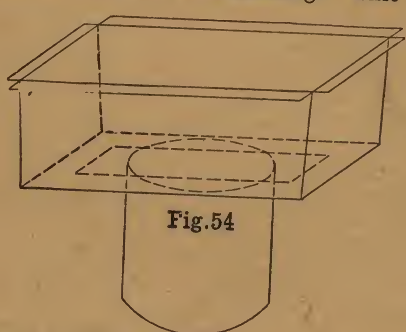


Fig.54

of setting a register box into the floor, although in my opinion not nearly so safe a way as when a border is used. The size to make the register boxes for any size register is one-quarter of an inch larger both ways than the size of the register as given in the lists of the manufacturers; that is, if no border is used. For instance, for a $10''$x$14''$ register a box $10\frac{1}{4}''$x$14\frac{1}{4}''$ is the proper size, or for a $12''$x$15''$ register a $12\frac{1}{4}''$x$15\frac{1}{4}''$ box is required. All

the boxes of this kind are to have a $\frac{1}{2}''$ flange at their top turned outward so as to rest on the floor; the register is then simply set into the tin box with its flanges resting on to those of the register box, and both on to the floor at the edges of the opening for the same.

The box, Fig. 54, is the cheapest and easiest style made and is mostly used for first floors where the basement, cellar, or furnace room below have a lath and plaster ceiling. I may also add that they are used by many furnace men where the room below has no ceiling at all, but the flooring of the rooms above. It will be observed that the collar of this style of register box must be made sufficiently long to come down far enough to admit the proper joining and fitting of the elbows into the same under the joists of the floor. The collar should be made large enough to be a nice, snug and easy fit for the elbow or angle that is to join into it. When a border is used with a register, a better job is done than when no border is used in work of this kind. The measures of the boxes are to be suited to fit into the opening of the border. These openings vary considerably in the different sizes of borders. The following list gives some of the most generally used sizes; the larger sizes may be measured from the frames or borders as used, they not being used so frequently I have omitted them in this list. For a frame which goes with a 6″x8″ register the box has to be made at its upper end $6\frac{3}{4}''$x$8\frac{11}{16}''$ on the outside so as to fit nicely into the frame or border. A $\frac{1}{2}''$ flange is to be turned outward for the register box to rest into the recess of the border.

SIZES TO MAKE REGISTER BOXES TO FIT INTO THE BORDERS.

List No. 1.

Size of Registers as Given in the Lists.	Sizes to Make the Register Boxes. Measured Outside Under the Flange.
6 x 8	6¾″ x 8 11-16″
6 " 9	7″ " 8¾″
6 " 10	6¾″ " 11″
6 " 14	7″ " 14⅝″
6 " 16	6⅞″ " 16¾″
6 " 18	6⅞″ " 18 15-16″
7 " 10	7″ " 10½″
8 " 8	8⅞″ " 8¾″
8 " 10	8⅝″ " 10½″
8 " 12	8⅝″ " 12¾″
9 " 12	9¾″ " 12 13-16″
9 " 14	9⅞″ " 14⅞″
10 " 12	10 15-16″ " 13″
10 " 14	11″ " 15″
10 " 16	11⅛″ " 17″
12 " 15	12 11-16″ " 15¾″
12 " 19	13⅜″ " 19⅛″
14 " 22	14 15-16″ " 22 11-16″

The list as given has been taken from a prominent manufacturer's line of borders. There may be a slight variation from this list in the sizes of frames or borders as sold by different firms in the trade; if any differences

occur from the sizes given, allowance must be made in the measurements for the register boxes when the same are made up in the shop. There are some occasions where it is desirable to make the register boxes and the pipes leading to the same double. I may also state that with some furnace firms this is the only way they put in pipes, register boxes and fittings. This is a rather expensive way of putting in the work, and as a consequence is only used by furnace men when no other or cheaper way can be adopted, when it is imperative that all the heat possible is to be conveyed into the room above and that none radiates through the pipes conveying the same though the rooms in the cellar. This is often the case where a pipe runs through a vegetable or storage room which it is desirable to keep at a cool temperature. Double pipes are also used when the warm air pipes are in a particularly exposed position, as in a cold basement or cellar. Making them double prevents them from chilling, which has a tendency to retard the easy flow of the warmer air inside of the inner pipe, which would be the case if the same were made single only, and fully exposed to the colder outside air. These few reasons explain in brief why and where double pipes may be used to advantage both for the user of the furnace, who can obtain the amount of warm air necessary to heat a given space more economically, and also to the furnace man who can thus heat more space with less radiating surface of his furnace.

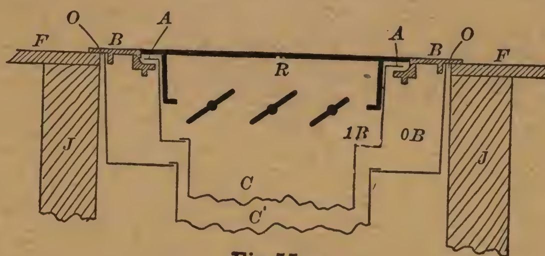


Fig.55

Fig. 55 gives the position which the register boxes (which fit into the borders or frames) occupy at A A. The preceding table gives the sizes for the same when done. The letters I B, of Fig. 55, give their outlines. R is the register in question. B B is the frame or border. J J are the supports or joists of the floor. F F is the floor. The register is shown set on the floor with its flanges. This is the usual way of setting it if the room is carpeted. The outside tin box is shown by O B. and its flanges resting on the floor underneath the flanges of the border at O O. When a register and frame or border is used or put into a hardwood floor, the frame is generally let into it so that the top is flush with the surface of the floor. The register box, as a matter of course, is also let down at the same time

into the groove cut into the floor. C C′ shows the collars of both the large and smaller register boxes. Fig. 56 shows different ways of fastening the collars into the openings in the bottoms or sides of register boxes. A shows the most common way. A strip is riveted on the outside of the collar; a $\frac{1}{4}''$ edge is first turned on one end of this strip, and it is then slipped over the collar and down far enough, so that the collar projects $\frac{3}{8}''$ to $\frac{1}{2}''$ beyond the edge turned on the strip. This projecting part of the collar is

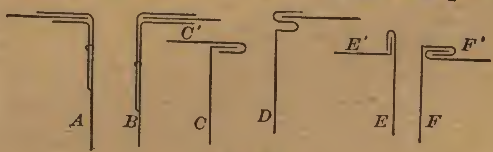


Fig.56

then notched and slipped into the opening for it, and turned over. A shows how it looks when finished in position, and also gives a view for a collar which slips over the outside of the connecting joint or elbow. B shows how a collar is arranged when it is intended to slip into the connecting piece of pipe. C shows a style used by some furnace workers to fasten the collars. C′ is the bottom of the register box. D shows still another mode. E and F show how to double seam a collar on to a bottom. E′ and F′ are the bottom of the box while E and F are one side of the collar. Fig. 56 shows so clearly these various modes to accomplish the desired results that no further explanation in regard to these fastenings are needed to make them understood.

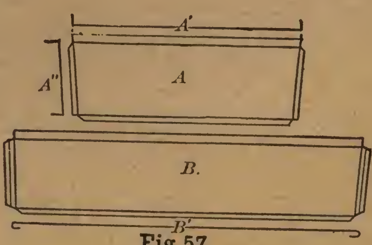


Fig.57

To cut the patterns for the style of register box shown by Fig. 54, one way is to make the sides and ends out of separate pieces as in Fig. 57, A for the shorter or end pieces, and B for the long or side pieces. Allow for all four pieces of each box one-half inch flange at its top edge; on the bottoms $\frac{1}{8}''$ for the straight outward turn. The same at the ends of the smaller end pieces, while at the ends of the long or side pieces allow $\frac{1}{4}'$ or enough for an outside double seam. A′ and A″ shows how the edges are to be turned for the ends and B′ shows how the end locks of the sides are to be turned. The bottom is to be double-seamed to the side and end

pieces after they are joined in their proper shape. In laying out these patterns they should be cut so that when the boxes are completed they taper somewhat from the top end toward the bottom. This is plainly shown in the figures. Another way, and at the same time a cheaper one, to make these boxes is shown by Fig. 58. In this figure a sheet of 20″x28″ tin is shown. The full measurements and data for the pattern of a 10″x14″ register box are given. The corners are to be lapped as shown by the dotted lines. Mark off the box to whatever size it is wanted; if a larger size is desired than can be cut out of one single sheet, as for a 12″x15″, add a piece to the same, or put an extra end or side in the box. When the pattern or the shape is cut, the lap for the corners allowed and the ½″ flange is turned for the upper flange, the sides and ends may be turned to shape as wanted; then turn the corner laps and fasten them by three or four 10 oz. rivets for each lap at each corner. This method makes an easy, cheap and good enough register box for almost any job. Many furnace men use no other style of register boxes for ordinary work. It is understood that the furnace man will have to make his measurements for patterns conform to whatever size register or frame he wants his box to fit. The solid line circle and also the dotted oval in the bottom of the register box of Fig. 58, show a 9″ round and a 10″ oval opening for the collars; either can be used for this size box as the occasion demands. The larger collar can be made to fit by making its shape slightly oval, as is shown in Fig. 58.

The following table gives the sizes to make the boxes which are to fit into the floor openings around the outside borders, as at O, O, Fig. 55.

LIST No. 2.

Sizes that Designate the Borders that Fit the Registers as Given in the Lists.	Sizes to Make the Register Boxes and the Openings in the Floor to Admit the Border and Register Boxes.
6 × 8	10½″ × 12½″
" " 9	10½″ " 13½″
" " 10	10½″ " 14¾″
" " 14	10⅝″ " 18¼″
" " 16	10½″ " 21¼″
" " 18	10¾″ " 23″
7 " 10	11⅞″ " 14⅞″
8 " 8	12⅝′ " 12⅝″
" " 10	13⅛″ " 15″
" " 12	12¾″ " 16½″
9 " 12	14⅛″ " 17″
" " 14	14″ " 19⅛″
10 " 12	15″ " 17″
" " 14	15½″ " 19½″
" " 16	15⅜″ " 21⅜″
12 " 15	16½″ " 19¾″
" " 19	17⅜″ " 24⅛″
14 " 22	20⅛″ " 27¾″

In the foregoing list I have only given the sizes that are most used in

ordinary practice. This list also corresponds to the one given for the sizes of register boxes that are for the inside connections. It is also for outside boxes when double connections are made. The holes in the floor may be cut a trifle larger than the sizes given for the register boxes.

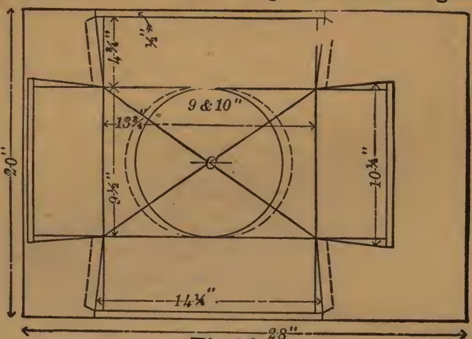


Fig.58

Fig. 59 gives a style of register box made for occasions when it is necessary to get the inlet as high as it possibly can be made. This is sometimes done to get greater elevation for the hot air pipe leading to the inlet. In case the ceiling of the cellar is plastered it is of no particular advantage to use this style of box in preference to the shallower kind shown in Fig. 54. But in case there is no plaster ceiling in the cellar,

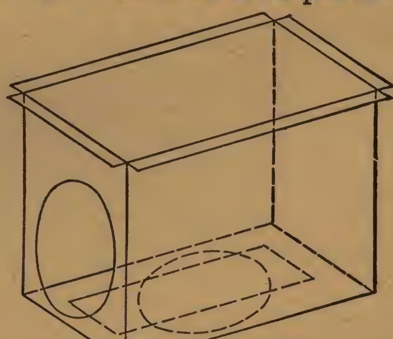


Fig.59

that is, the floor above the joists serving as the ceiling for the cellar, basement or furnace room, this register box, Fig. 59, can be used to advantage by making the connection in the same from either one of the ends or in the sides. I have, at times, used a deep box of this kind where it was desirable to keep a pan, or some contrivance which would hold water, suspended in the same in order that if the air discharged from the furnace was too dry or hot the water contained in the pan would impart the desired degree of moisture to the air of the room as demanded for the pur-

pose for which the room was to be used, whether as a conservatory or a green-house, etc. This style of box is often used for second or upper floor connections and registers. Fig. 60 gives a view of a deep box connected

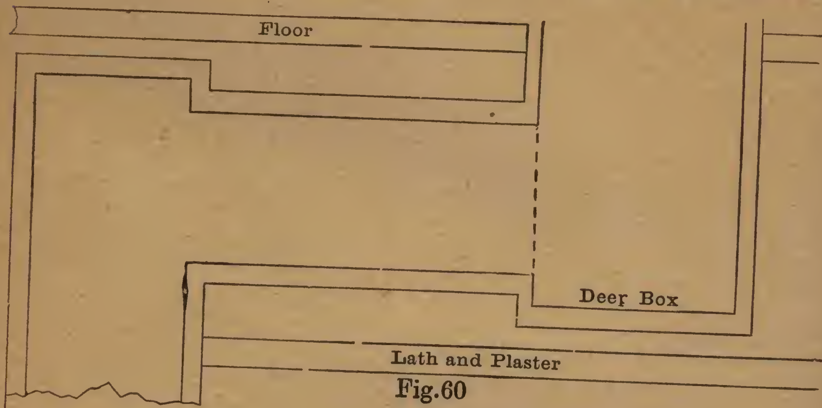


Fig.60

with a stack in the manner described above for a second or upper floor connection. When boxes are made for large registers they are generally made in four parts, as the material in many cases is not large enough for them to be made out of less pieces. Fig. 61 is a good

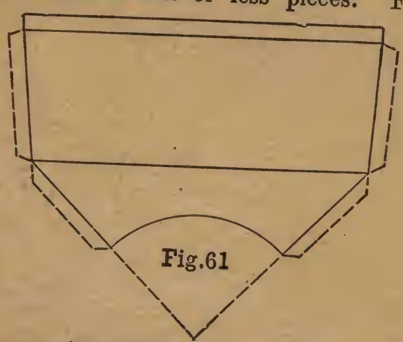


Fig.61

pattern to make them after. One side and one quarter of the bottom are shown, with a quarter of the hole cut out, which fits the collar. In Fig. 61 all the laps are given for two parts; the other two parts of the register box lay on to these laps and are riveted to it. The same is done on the bottom. This makes a good strong box. The larger sizes of register boxes are generally made of galvanized iron, while the smaller sizes are made of tin, and in some cases are made double. It is seldom that a register box larger than 18″x20″is made double. The larger sizes are generally used for large spaces, such as halls, churches, stores, etc., usually only one or two outlets being used from one furnace.

In connection with this subject it may be well to describe the opening in the plastered ceiling of the cellar through which the hot air passes to connect with the register box collar, and also how to protect it so as to render it safe from over-heating. When a house is being built, and before the lathers have done the ceilings of the basement or cellar, find the locations where the registers are to be placed in the rooms above. In the center of these positions (or where you are going to locate the collars in the register boxes) directly underneath the floor joists, nail or fasten in position the ceiling rings, or, as some term them, plaster collars. Fig. 62 shows what is meant. These plaster collars are made, for new work, about $1\frac{1}{4}''$ wide and $\frac{3}{8}''$ larger in diameter than the pipe or elbow (which is intended to supply the register above) which passes through the collar into the register. Straps are riveted to each side of the plaster ring and nailed to the joists, as in Fig. 62.

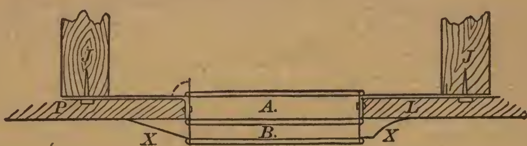


Fig.62

After the plaster collars or rings are put in position the lather can nail the laths in their proper places and the plasterer may finish around the ceiling ring. In case the ceiling has been plastered and finished before the holes for the pipes or collars have been cut, as would be the case in an old building, I would recommend that the hole be cut as near the size and shape desired as the skill and ability of the workman can accomplish. Make it a point to do as good work as you are able to do. Then put a band about $2\frac{1}{2}''$ wide on which a collar, say from $2''$ to $3''$ wide, has been secured, as in Fig. 62, in position. Have the top end notched down so that this end can be cleated down far enough on the laths to draw the collar up firmly against the plaster underneath. This makes a fine-appearing finish around the pipe which enters through this style of plaster collar or ring. A and B are the collar for a finished ceiling and X, X are styles of flanges that may be used for this purpose. J, J are the joists; L and P are the laths and plaster. Fig. 63 shows a well designed shape of register box with the collar at one end. This style of box is often used for first floor registers when the conditions are favorable for such a shape to be used although it is more properly a second or upper floor register box. This shape is mostly used on these floors when a deep box is demanded. The end opposite the collar, it will be noticed, is cut off or made in such a shape as to give the entering warm air an upward turn

toward the register outlet. The wire netting placed on the inside of this register box serves to hold a vapor pan as has been described in connection with the box, Fig. 59. This shape for a deep register box is a very good one. Fig. 64 gives a box of the same general design as Fig. 63 with the

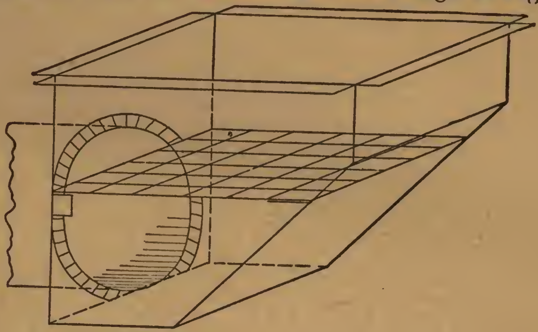


Fig.63

difference that it is more shallow and has a square or rectangular inlet collar instead of a round inlet as in Fig. 63. This style is used by many furnace men and is a good shape for the puıpose.

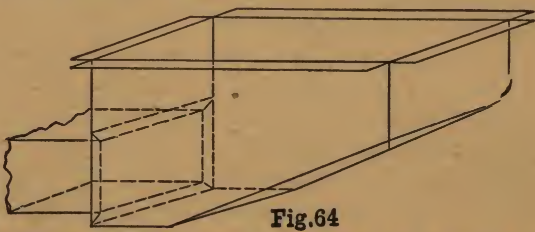


Fig.64

Fig. 65 is about as good a shape as could be designed for a register box for an upper floor connection. The design shows every point so plainly that no detailed description is necessary. Fig. 66 is another style used to

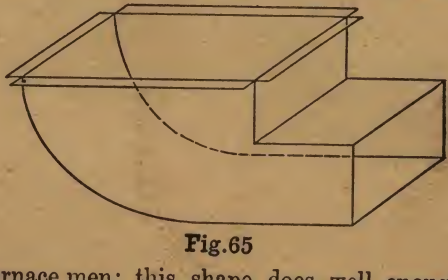


Fig.65

some extent by furnace men; this shape does well enough in some cases, but I would not recommend it for general use.

It will be observed that three flanges of the top end of this box are

turned straight upward. In some cases where connections with a round pipe are made under the floor it is very convenient to have the flanges so arranged that the box can be let down through the opening cut in the floor and the connection made with the lateral pipe and the register box collar between the floor and the lath and plaster ceiling of the room below. When the connection is made the box may be drawn up into place and the flanges then turned down on to the floor into their proper place.

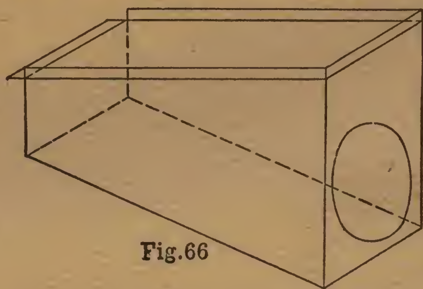


Fig.66

Fig. 67 gives a view showing how the connections are arranged underneath the floor to a register on one side of a stack as shown in Fig. 67, the stack at the same time having another outlet on its opposite side leading to another register in a different room. It will be seen that the stack has a division plate in its center, so as to divide the air equally that each register may get an equal share of the ascending heat. Make the dividing plate downward in the stack at least three or more feet long. The connecting collars are shown cleated into the stack. At the end A, of Fig. 67, or the horizontal rectangular connecting pipe, is shown a method used when on regular register box is used to provide an outlet for the register to fit into. A

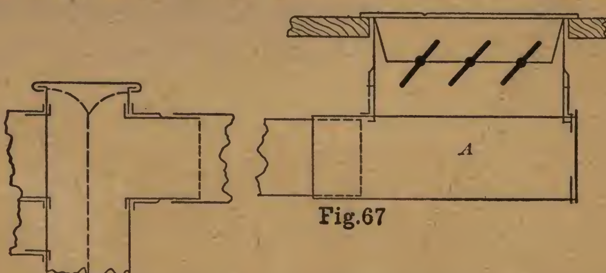


Fig.67

four-sided, rectangular shaped collar or piece of pipe of the required size to fit the register is made; this is turned over on to the frame or floor, as the case may be, and its lower end is cleated into the horizontal connection, as shown in the Fig. 67. It often occurs that a stack connects directly into the bottom of a register box. In a case of this kind, make a collar to fit

snugly over the stack and cleat the top end of the stack firmly to the bottom of the register box. This tends to making a good, solid job, and also helps the appearance of the joint a great deal, more than if the same had only been slipped into the collar of the register box and left in this condition. The dotted lines in Figs. 54 and 59 on their respective bottoms show how the same would appear if the stack entered either one of them at that place.

XIV.

PIPE DAMPERS AND DRAFT REGULATORS.

Of dampers and draft regulators there are a great many different styles and kinds used in furnace work. I will give a description of the kinds generally in demand, the various purposes they are best suited for and also how they are made. In connection with this the necessary tools to make these dampers will also be given. Fig. 68 shows a hot air pipe

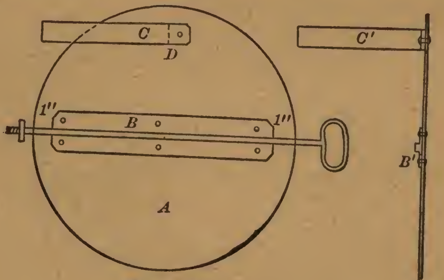


Fig. 68

damper. This style is used more than any other, being a favorite with most furnace men. The reasons for this are: They are cheap, easily made and stronger than most other styles used for the sizes of hot air pipes below 12″. For larger sizes the material and also the general construction of the dampers should be stronger and heavier. For dampers of any size that are to be used for the purpose of shutting off the flow of air through hot air pipes it is imperative that they are made so that they fit well, that is, that they really do the work they are intended and designed for, namely, completely stop the flow of air through the pipes into which they are placed. If a damper disk is cut too small or even if the same fits somewhat loosely, it is obvious that it cannot efficiently fulfill its purpose. I have seen dampers placed in hot air pipes that fitted so loosely that even after they were turned or closed the diminution of the flow was very little.

In fact it would have been better if the damper had not been placed in the pipes at all as far as their practical value was concerned. About the only reason why a damper is put into a hot air pipe is to cut off the flow completely, it being very seldom desired to only partially cut off the supply in the smaller sizes of pipes. For this reason a good, snug fit is necessary to

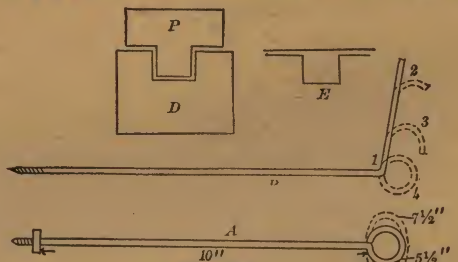


Fig. 69

obtain the desired results. Make the disk of the damper so that the same exactly fits into the inside of the pipe it is intended for, thus assuring a good job It is the custom in some shops to make the dampers a little larger than the pipes are on the inside. When the dampers that are made in this way are put into the pipes they spread the same to some extent; then

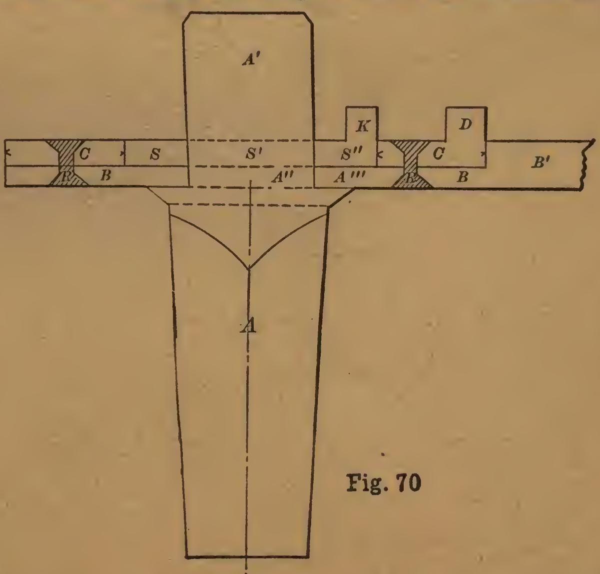


Fig. 70

when the damper is turned too close, or to shut off the flow of air through the pipe it has a tendency to force the shape of the pipe from round to oval. It is true that this mode closes up the pipe, but it takes considerable

force to squeeze the damper into position to accomplish this. The above mode I consider a very poor substitute for a damper that could have been made correctly if the proper way had been followed in the first place.

Having shown what and how dampers for hot air pipes should be, I will give a detailed description of the dampers as shown by Figs. 68 to 73. The first consideration when dampers for hot air pipes are made is to select a suitable material from which to make them. This depends in a measure upon the size required, the purpose and the location in which it is intended to use them.

It is the custom in some shops to use almost any old scrap iron or even pieces of tin for the disks of the dampers. Frequently the pieces are not large enough to make a whole disk; this makes it necessary to join or rivet a piece or two to it. This practice is allowable if neatly done, but it should never be done where it is the point to save time in making and getting out work of this kind. The best mode is to use a whole piece for the disk of any sized damper. Make it for the smaller sizes, below 12″ or 14″, of 26 gauge iron; for larger sizes, of 24 to 22 gauge. This makes this part of a damper as it should be, namely, strong enough to do the work demanded of it. If the disks are made of lighter material than as given above there is always danger of buckling and bending out of shape when in use. A damper, as Fig. 68 shows, consists of the following parts: A is the disk; B is the strip which fastens and holds the rod firmly to the disk; C is a stop riveted to the disk as shown. This stop is bent at right angles to the disk at D. The position it assumes is shown by C′ in the side elevation of Fig. 68. The strip B is riveted to the disk with six or more rivets in the manner as shown. In length it would be well to make the same as the measurements give in Fig. 68. The strip C is to be made in length long enough so that the damper when open cannot be turned any farther in the direction from which it has been opened, than the center, or wide open.

Having described the parts which constitute a damper, that is, all but the handle, I will next describe how the different parts are made and also some special tools for this purpose. The first operation is to get out the disk; this done, the handle or rod may be made. Rods or handles for dampers, up to 16″ in diameter, are generally made of $\frac{1}{4}$″ square rods; for larger size dampers, $\frac{3}{8}$″ up to $\frac{1}{2}$″ square rods are the proper sizes to use. When the rods for the smaller sized pipes are made the proper length to cut them depends upon what kind of shaped handle it is desired to have at the end of the rod. I will assume a handle or rod is wanted for a 10″ damper. Cut the rod, if a round ended handle is wanted, $16\frac{1}{2}$″ long; this gives 1″ for the straight end outside of the pipe, 10″ for the damper and $5\frac{1}{2}$″ for the handle end, or the end where the eye or ring is turned. These

measurements are fully shown at A of Fig. 69. If an oval shaped handle is desired, the length is to be $7\frac{1}{2}''$ instead of $5\frac{1}{2}''$ as for the round one, making the entire length to cut the rod $18\frac{1}{2}''$ for this style. To form the eye to shape, if this is done by hand, see B of Fig. 69. Make the bend at 1. Then commence to form the eye as the shape at 2 to 3 and finally at 4, the completed eye, shows. It is always well to heat the rod before turning the eye, as this makes it an easy operation. It is the custom of some furnace men to do the turning of the eye when the material is cold; this, as will be readily understood, is a very uncertain and laborious way of attaining the desired result. There is always more or less danger of breaking the rod when the same is hammered too much while bending it when cold. I would advise heating the rod and never attempting to bend one while cold.

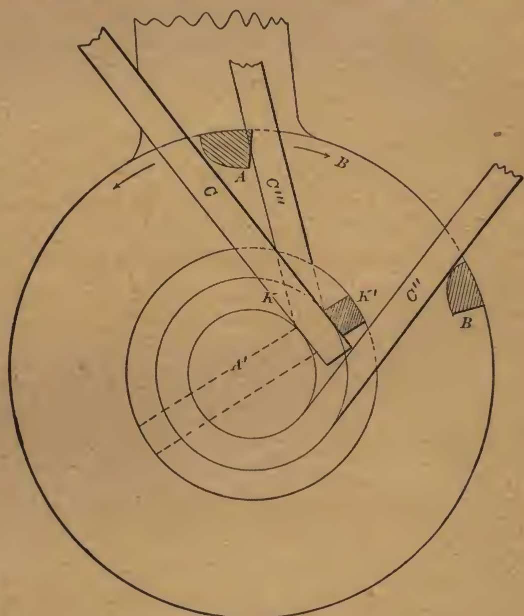


Fig. 71

Figs. 70 and 71 show two views of a handy tool to bend the eyes or round handles on damper rods. Fig. 70 gives a sectional view, one-half of the actual size that this tool is to be made. The part A and A′ is to be made of one solid piece. The part A′ is to be made round down to the line A″; then the projection A‴ outward is to be made as shown, to support the other parts of the tool. This part is to extend outward all around. The part A may be made square, so that the tool may be fastened in between the jaws of a vise when using the tool. The part B, B is a disk made to

size as the drawing calls for, with a handle about 10″ or 12″ long, firmly attached to it as B′ shows. This disk B, B has a hole cut out of its center, the same size or large enough so that it fits over the part A′ and when in position rests on the ledge or projection A‴, as in Fig. 70. Another disk, as given by C, C, is riveted to disk B, B; the hole out of the center of disk C, C is to be as large as the drawing shows. This disk is to have two projections as shown in the plan, Fig. 71, at A and B, and at D, of Fig. 70, for elevation. At S′ a piece of steel $\frac{1}{4}$″ square is fastened as shown by S, S′, S″ for elevation. This piece of square rod is to be shaped and is to run through part A′ as in both Figures 70 and 71. This holds the disk A down in its proper place and at the same time supplies the projection K of Fig. 70 and K′ of Fig. 71. The foregoing gives all the parts for this tool. It is to be borne in mind that the drawings are only one-half size of the actual tool described and represented by them. The operation of bending the eye by a tool of this kind is set forth in the Fig. 71. The rod C is shown in the position when first placed in the tool. The arrow marks the direction the disk is turned around in until the rod is bent to the position it has at C″. The operation of bending the rod so that the eye comes in to the position it is to have when the handle is done is shown at C‴. Bend the handle or turn the disk in the direction the arrow B directs until the desired shape is obtained. K to C‴ illustrates how the eye is to be placed on the tool so that the last described operation can be performed. It is best when bending the eyes with a tool of this kind to heat the rods to a red heat so that a good job can be done. The tool, or, as some name it, the bending machine, is one of the simplest kind made for this purpose. It does the work easily, quickly and perfectly, and is as cheap and durable a machine as could be conceived of this class. Fig. 69 also gives the end views of a die and plunger used to bend to shape the strips used to hold the damper rods to the damper disks, as B of Fig. 68. The measurements to make the die and plunger are to be according to the size rods which are used. If $\frac{1}{4}$″ rods are to be used the groove in the die is to be $\frac{5}{16}$″ deep and of the same width. The plunger is to be $\frac{1}{4}$″ wide and $\frac{1}{4}$″ deep, the same as the rod it is intended to bend the strip for. D and P only give an end view; the length of this tool may be made as best suits the person who will use it. E gives a view of a piece of iron laid on the face of the die ready to be formed in shape as demanded for a strip of this kind. Another way used by some workmen is to form these strips by using the jaws of a vise for a die. The vise is opened to whatever distance it may be necessary, so that the jaws are the right distance apart to form the strip correctly. The flat piece of iron is laid flat on the jaws and a piece of rod is laid on the strip directly over the opening of the vise. The piece of rod is then ham-

mered down so that it is flush with the top of the jaws of the vise with its top side, while the two vertical sides and the bottom are enveloped by the shape of the strip just formed. The above method is used by many furnace men for want of a better way. The plunger P is also driven down by a hammer or, a better way, by a wooden maul.

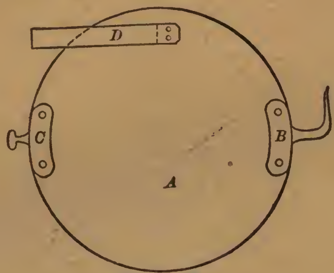


Fig. 72

Fig. 72 shows a handy style of fastening for the smaller sizes of hot air pipe dampers. A is the disk, D is the stop or check, B and C are the handle and the opposite fastening. These trimmings are sold by supply houses almost all over the country. They are made of malleable iron and are cheap though not as strong and stiff as the handle of Fig. 69. They are used by many furnace men for dampers. One point that the workman should be particularly careful about is to be sure when putting dampers into hot air pipes to have them in even and true in the center, so that when they are turned to close off the flow of air they do so completely. It is readily seen that unless dampers are put into pipes as described they cannot possibly do the work satisfactorily.

Fig. 73 shows a mode used for a damper in a large size pipe. The shape of the handle of the rod is given at A. At B an end view of a gauge to regulate the damper is given. A side view of the gauge is shown by D. This gauge is fastened to the side of the pipe above the hole through which the damper turns; holes are made into the gauge and by the peculiar shape of the end of the handle one is enabled to push this end into these holes in the gauge, thereby regulating or setting the damper at any angle as may be desired. It is advisable to place strengthening plates at the points where the rod passes through the pipes, as shown at E. I may also add that it is good policy to provide every rod of the kinds described with a thread and nut as shown in the drawings.

The foregoing arrangements of rods for the dampers as described are all made so that it is necessary to turn the same downstairs or in the furnace room. The Figs. 74 and 75 show a damper and regulator so arranged that the turning and regulating may be done upstairs or in any of the

rooms above. The Fig. 74 shows a damper in a large pipe. It will be noticed that the rod is straight throughout its entire length. A handle, as the drawing shows, is to be fixed firmly to the end, a counter balance or

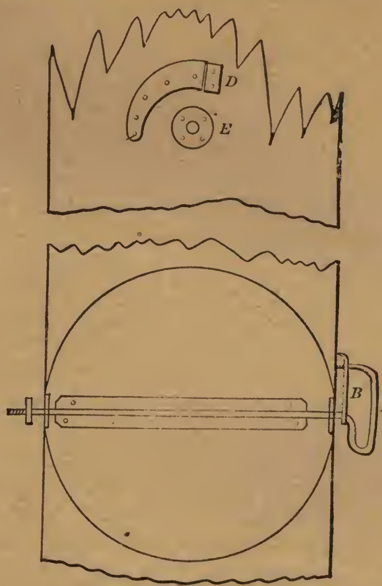


Fig. 73

weight is to be placed and so arranged that it either closes or opens the damper as the workman se s fit to determine. In this case I will assume that the weight is so arranged that it opens the damper at all times if no

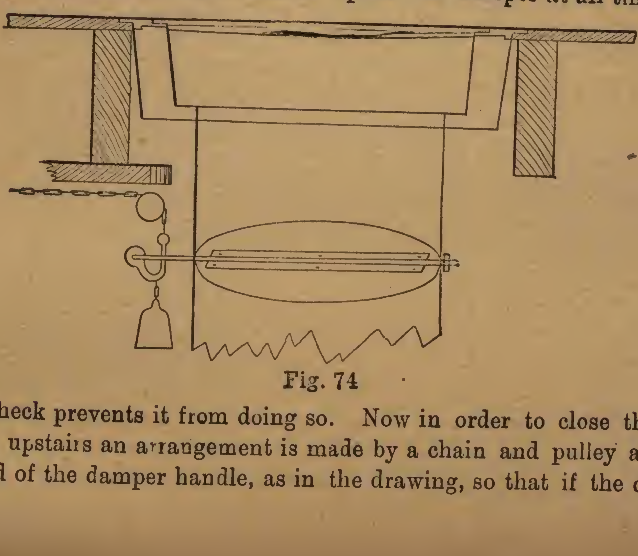


Fig. 74

counter-check prevents it from doing so. Now in order to close the damper from upstairs an arrangement is made by a chain and pulley attached to the end of the damper handle, as in the drawing, so that if the chain is

drawn up it will close the damper. Fig. 75 shows one of the neatest and at the same time most serviceable damper regulators made. This appliance consists of a rod, as A gives, provided at its upper end with a fancy knob to draw the rod up or to push it down as described. B is a guide-post screwed into the baseboard. C is another guide-post, but is at the same time provided with a set screw so that the rod can be fastened or set at any desirable height or position the damper, which the rod controls, is to be set at. At X is shown a pul-

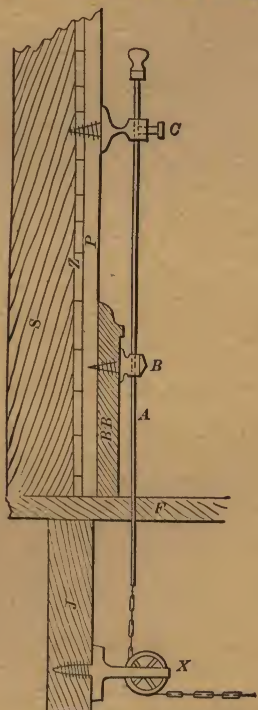


Fig. 75

ley on which the chain attached to the lower end of the rod runs. These rods and trimmings are generally made of brass; some are nickel-plated, or even silver or gold-plated as may suit the ideas of purchasers. The letters B, B shows the baseboard; J is the joist; S is the studding; L are the laths and P is the plaster. These rods may be attached to almost any kind of a damper used in furnace work and at the same time may be at any distance away from the damper that they operate.

Of smoke pipe dampers, the kind most commonly used is shown by Fig. 76. This damper is made similar in its general design to the hot air pipe dam-

per, as in Fig. 68, with the difference that in all its particulars it is heavier and stronger and also that in every case where a damper of this style is used a 2″ hole should be cut out of the center part of the disk. This figure shows a somewhat different style of fastening for the rod. The style as shown may be used if it is preferred by the furnace-man. Figs. 77 and 78 show two views of a simple check. This arrangement consists of a number of slots being cut out of a straight piece of pipe. These may be about 6″ or 7″ long and about 1″ wide. This is for the inner part; the outside part is to have the same number of openings, and is to fit nicely over the inner part, allowing the outside part or cover to slide back and forth easily. Fig. 78 shows the damper closed. The lug may be so arranged that the damper can be regulated by a chain from up-stairs.

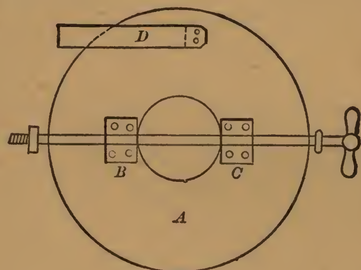


Fig. 76

In making this check it would be well to first get the two parts ready to be put together, then swage the bead C or D as preferred, slip the outer part over the slotted part of the inner piece and then swage the other bead as shown. This secures the outer part from coming off from the check. Suitable stops are to be provided so that the outer part cannot turn any farther than is necessary for the proper working of this check or damper. The check can also be made so that it can be operated from up-stairs by a chain if suitable counter weights are attached to the sliding or outside part of the same. Fig. 79 shows another style of check for the same purpose as Fig. 77. The broken end is made long enough to fit on the smoke collar of the furnace, the part B is a tee attached to the straight pipe and is the smoke outlet for this check. Part A is made solid its entire length, which is shown from A to C. The part D is a perforated sleeve which fits into A and has a solid cap provided with a handle at D. When the part D, D′ is drawn out from part A the cold air rushes in the smoke pipe, thus checking the draft to the extent of whatever length the part D, D′ is drawn out. The holes cut out of part D, D′ may be from $\frac{1}{2}$″ to 1″ in area. This style as described is one of the simplest and cheapest checks made, and is also a

very good one for the purpose. Fig 80 shows a check with a cast iron end piece, as A, A′ gives; this is secured to the straight piece by rivets or bolts, and the cover as shown is operated from the upper floors by the regulator with chain and pulley. I have also shown a damper placed into the tee. This damper is of the style shown by Fig. 76.

It sometimes occurs that a furnace is set in such a position that it is impossible to use a check straight out as the style Fig. 80 would be. If a case should occur that it would be necessary to put the check out from the side, as the circle B of Fig. 80 indicates, it would become necessary to make two tee junctions at this place and a cap would have to be made to close up the end at A′. Fig. 81 shows the view that the two tee pieces and the end

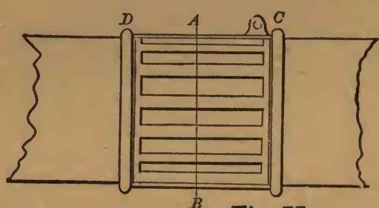


Fig. 77

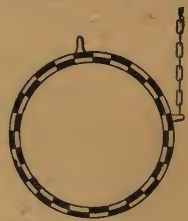


Fig. 78

would present if the check were placed on the side. In order to get the patterns for the pieces wanted, draw the view, Fig. 81, to the full size required. Above the line A, A draw the semi-circle B; divide this into any number of equal parts as may be desired. In this case I have divided it into eight equal parts. Drop from these points as found the lines 1 to 9, as shown, to the circle D. Draw the line X to X′ at right angles to the numbered lines. This gives the data from which to lay out the pattern, as Fig. 82 shows. To lay out the pattern make the distance from 1 to 2 equal in length to the circumference of the pipe as desired. Make the distance be-

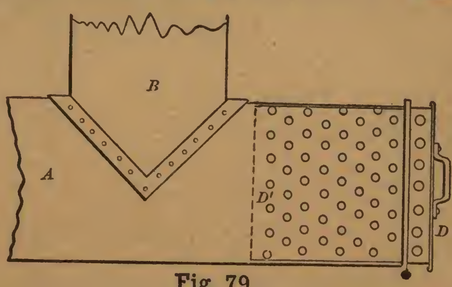


Fig. 79

tween the lines 2′ and 4 equal to the distance between the lines 3′ and 4′ of Fig. 81. Next divide the line 2′ into twice the number of equal parts the semi-circle of Fig. 81 is divided into. The distances contained between the

space bounded by the line X to X′ and the curve of the circle D, of Fig. 81, are to be transferred to their respective corresponding lines of Fig. 82. The distances thus found and transferred give the outline of the miter joint of the required patterns as is shown in Fig. 82. The above description merely gives the outlines of the pattern; as both the connections are alike, one pattern does for both. All locks and laps are to be allowed for these parts. Checks of this kind are generally made of iron not lighter than 22 gauge.

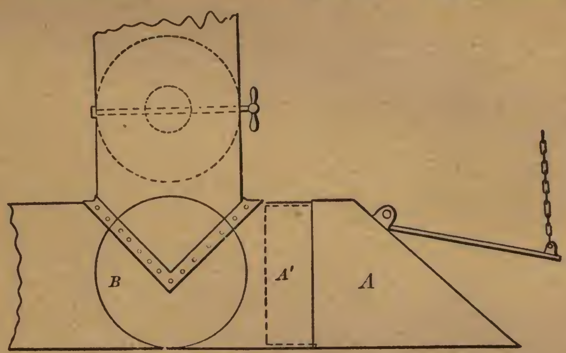


Fig. 80

Fig. 83 shows a method whereby to arrange a damper in a square pipe, in case the stack or pipe is to supply two rooms, one above the other. The damper is generally placed in the pipe immediately above the register which supplies the lower room with warm air. The damper in cases of this kind should fit snugly against the sides of the inside pipe. The rod may have a disk (which has suitable openings provided for regulating and setting the damper) to work in as is shown by the side view of Fig. 83.

The piece A attached to the rod as shown fits in the openings of the disk, which is fastened against the wall, thus permitting air which passes through the pipe to be regulated at will.

Fig. 84 illustrates how to arrange a damper for two pipes that are supplied by one pipe only. It often occurs that two rooms on an upper floor could be supplied as indicated in the above, particularly if only one room is to be used at a time. The arrangement is so clearly shown in the drawing that no further description for this figure is deemed necessary.

Having described some of the leading kinds of the ordinary styles of dampers used in furnace work throughout the country, I will give a brief description of what are called automatic, electrical heat governors, draft regulators, etc , or in short, dampers used for the same purposes as those described in the beginning of this article. That there is a difference in these latter appliances from those that are ordinarily made by furnace men becomes at once apparent to the would-be-purchaser and user of one of

these appliances for the ends sought. This difference is in their enormous first cost as compared with the ordinary styles in general use. This item of first cost is of course the main reason why these systems will not be used to the same extent for hot-air heating apparatus of moderate cost, as they are for the higher priced hot water or steam heating plants. These latter systems in dwelling-houses may require some such arrangement as the numerous automatic and electric heat and pressure regulators promise to give to the users of these plants; namely, a more assured feeling of safety from the real or imaginary dangers of overheating, or too much pressure in the boilers of their heating apparatus.

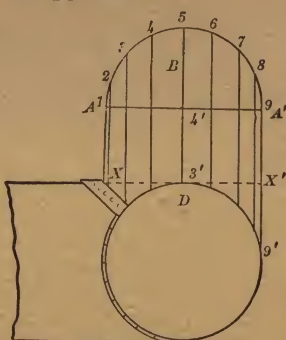


Fig. 81

One of the cheapest automatic appliances to regulate the heat supply of a furnace I will describe. The arrangement consists of a hollow brass tube, inside of which an iron rod is fastened so that when the heat becomes of a higher degree in the air-chamber of the furnace than is desired, the iron rod pushes against a lever, which in turn lowers or raises a damper

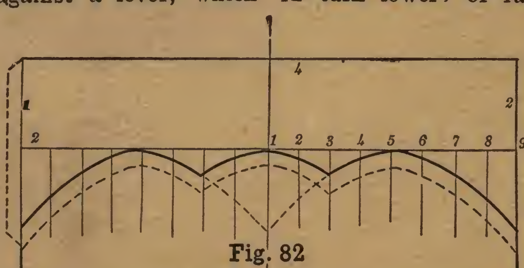


Fig. 82

in the smoke pipe of the furnace, thus causing the fire in the furnace to be checked if the same is too great, and also, if the furnace becomes too cool, the bar by reason of its getting cooler and contracting, allows the lever that caused the damper to open, now causes it to close. This, as a consequence, causes the fire to burn or have more draft. It is plain to be seen that the

operation provides a good method to prevent the furnace from over-heating, but at the same time, it cannot be of any service in case the furnace becomes too cold or the fire becomes too low. This, by reason that it closes the damper whenever the rod is at a lower temperature than it is set at to open it. The foregoing simply demonstrates the fact that as a preventive measure to avoid the over-heating of a furnace such an appliance may do well enough, but for the purpose of giving the occupants of the rooms above the furnace room any warning that the fire is getting too low in the furnace, its efficiency is practically *nil.*

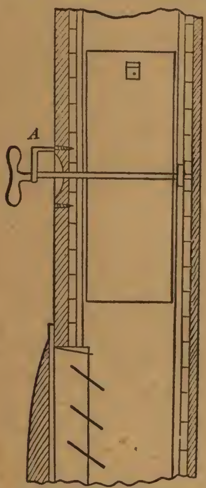


Fig. 83

Fig. 84

A brief description of the more costly kinds of temperature regulators may not be out of place here. The first point that nearly all manufacturers of appliances of this class claim is that they have the best and only perfect-working arrangement for the purpose that is made. This assertion is seemingly backed up by the high prices charged for these devices. To illustrate: In an estimate furnished for the fitting up of a house with a complete system of electrical regulators for a furnace and the pipes of a house the cost was estimated at $275.00, while the furnace, piping and all the parts and pieces appertaining to the furnace proper, complete, cost in the first place only $185.00. This would have been a rather costly set of dampers, and it is needless to say that in this instance they were not put into the house. The owner, although realizing the many good points of this kind of an apparatus, could not quite see where he could get $275.00 worth of benefit out of the same, and mainly for that reason did not have one put into his building. I may remark in connection with this subject that there

is a good field for some manufacturer to get up a low-priced apparatus, as indicated in the foregoing, which must be simple in all its parts, and also reliable as to the performance of the work demanded of it.

Some manufacturers of these appliances sell automatic electric damper controllers, while others depend upon the regular winding of clocks to insure their steady working at all times. Some of these latter kinds, if the temperature should fall below a certain desired degree, or if the same should rise above the degree that the indicating thermostat is set at, ring an alarm-bell and at the same time open or close the dampers, as the case may be.

The general working of an automatic electrical apparatus may be described as follows: In each of the rooms of which it is desired to regulate the temperature a regulating thermostat is placed in any convenient place. This thermostat again is connected with wires to the electrical valves which control the dampers in the smoke pipes and air inlets of the furnace. According to the system used, in some cases each hot-air pipe has a separate valve which operates a damper in the pipe in which it is placed. This, of course, according to the way the thermostat is set in the rooms above, either closing the damper, if the temperature is too high, or *vice versa*. It would be well for the student to make himself thoroughly familiar with the various styles and kinds of appliances now on the market. It would require too much space to give even a casual review of the many different kinds; and, as a knowledge of the details of their construction and operation is recommended, I would advise all those who care to go deeper into the subject to supply themselves with the descriptive circulars, pamphlets, etc., of the various firms throughout the country dealing in electrical appliances of this kind. They will gladly furnish any further information the student may want on this subject.

XV.

FURNACE HOODS AND COLLARS.

The subjects which I will describe next are the various kinds and styles of portable furnace hoods, the different ways in which they are made and also the various connections, such as starters or collars, thimbles, etc., used in connection with them in setting up furnaces. The figures from 85 to 90 give fifteen different styles and varieties of portable furnace hoods. These hoods are all made so as to be removable, and are made of galvanized iron. The proper gauge of iron to make a hood of is from 26 to as heavy as 22 gauge, according to the size of the hood and also to the pur-

pose and other conditions in connection with where the furnace is set. One very important fact, which it will be well to bear in mind when laying out or designing a hood for a furnace is to provide as roomy and large a covering for the furnace as the conditions and location in which the same is set will permit. The difficulties to contend with will be shown where in some cases it is impossible to give to the hood the proper height for the large storage chamber in the same, which, to obtain the best results, is necessary for the proper mixing and distribution of the air into the various pipes leading therefrom. These conditions must be met and overcome by the furnace setter in some way or other.

A very simple way is to make the casings as low down as possible and also to set the furnace low in the start. The idea is to always have the hood inside of such a height in the clear above the furnace that no less a space than twelve inches remains. A very good rule is to get as near eighteen inches in the clear, from the topmost part of the furnace to the bottom of the top of the hood, as possible. If the foregoing can be complied with, the student will find that he has the best possible conditions to assure the proper mixing of the air and also enough storage room in the hood, so that he can go ahead with this part of the work knowing it to be all right.

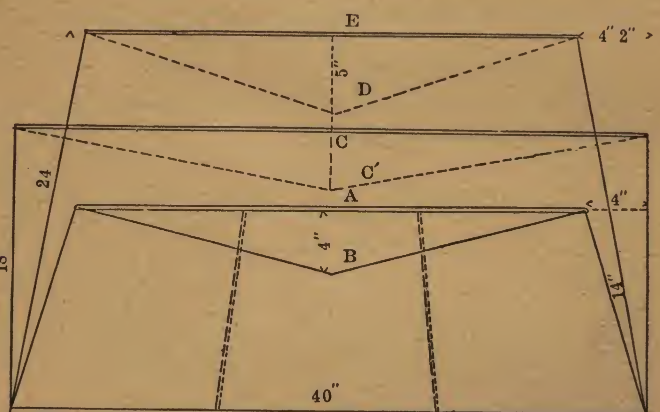


Fig.85.

Having shown what points are the most necessary for the proper design of a furnace hood, I will give the details and also the best ways of making the different kinds of hoods as shown by the figures 85 to 90. Fig. 85 shows six different hoods, three with flat tops and three with inverted cone tops. These styles are used by many furnace firms, particularly the kinds with the flat tops. The chief reason for this is that they are the simplest,

easiest made and as a consequence are the cheapest kinds made, especially so the style C, which has its sides straight up and down and the top of which is flat. It is in fact nothing more nor less than a continuation of the casing of the furnace with a flat top put on to it, the vertical cylindrical part being fitted to the top casing rings. This style of hood I would not recommend unless the point were to see how cheap a hood could be got out, and also if the hood were to be used on a furnace which would leave ample elevation for the pipes leading from it and at the same time have all the outlets or collars on the top of the hood. In a case where all the outlets are put on the vertical part or on the sides it is readily seen what a large dead space the top of the hood would leave, and this being the hottest part of it a good deal of heat would radiate and be wasted in the cellar or furnace room through this large surface. The best plan is not to use this style hood if it possibly can be avoided. An improvement could be made on this hood if the top were made in the shape of an inverted cone, as C′ of Fig. 85 shows. If the cone or top has a pitch of about 4″ or 5″ down, this will do away with the most objectionable feature, namely, the excessive radiation of heat through the flat top. If the collars are placed on the top they can be located around the outer edge, this being at nce the highest point and therefore the best place that they could be put.

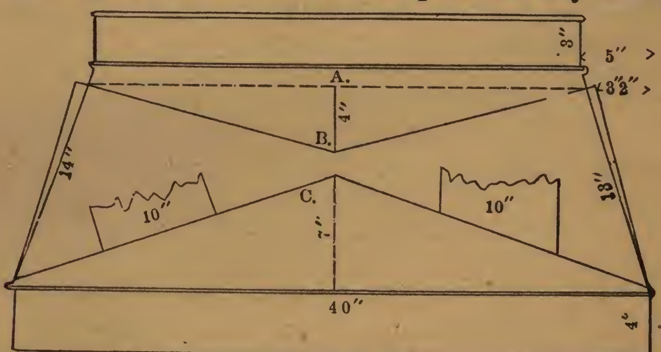


Fig.86.

After the furnace is set up and the hood and collars are all in position, the top of this hood can be filled up level to the outer edge with sand, which prevents the heat from radiating out through the top and instead directs it to its proper outlets, namely, the collars connecting with the hot air pipes. If all the collars are taken out from the sides at or near the top, the entire inverted conical top may be filled up level to the outer rim with sand, thus attaining the best possible results that could be expected from a hood of this kind. The object of putting a conical top on hoods is that by reason of the pointed shape which the underpart of the top at its center presents

to the volume of air in the interior of the hood it directs all the heated air to the highest part of the top where the collars or outlets are located, and also that on the outside of the top, where it is depressed by reason of the conical form, the space can be filled with sand or some other non-conducting material, thus preventing any unnecessary waste of heat from the furnace when in operation.

The hood as shown by A of Fig. 85 is a far preferable one in its entire design to the one given by C of the same figure. Although the top on this style is also flat, it has this advantage over the style shown by letter C that the sides are made in a conical shape, the body of the hood being made in the shape of a frustum of a cone. The conical-shaped hoods I consider the best for the following reasons: By reason of their being of less diameter or smaller at their top than at their bottom, they concentrate the heat more compactly, causing it to mix more directly and adding force to the flow of air through the outlets from the same at the hood, and, as a consequence cause a more rapid flow of heated air through the hot air pipes.

Although this style of hood costs a trifle more to make, the advantages gained by using this kind in preference to the style shown by C, far outweigh the extra cost. If a conical hood as described has an inverted conical top as B of Fig. 85, put on instead of a flat one, the best shaped cheap hood that could be produced is the result. The general practice is to make these hoods from 12″ to 14″ high. The lower edge of this hood is fitted to the top casing ring of the furnace. As will be noticed in the preceding, this height leaves but scant space for the accumulation of any volume of air in the air chamber. Some firms have (to meet this point) adopted the plan of making the hoods of their furnaces somewhat higher; the styles as given in D and E of Fig. 85 show what is meant. This makes quite an improvement over the other styles. The starters, collars or outlets, are of course, at the upper edge of these hoods. Fig. 85 gives all the main measurements as to height of the body or sides, also the angle of inclination of the same from the vertical, and the pitch of the conical tops. When making conical hoods as the Fig. 85 illustrates, a small burr is generally made at the lower edge of the hood inwardly, so that it lays up snug and tight to the casing ring on which it is placed. It may perhaps be well to add that a hood should always be made so that it fits well, and for that matter, so should all casings, etc., used on portable furnaces. The impression one would get from some work I have seen in this branch, would lead a person to believe that the genius who did the work on the casings and hood (that is, who fitted them as they appeared when

I saw them, without providing a regular inlet for the cold air to the furnace), intended to take the cold air from the furnace room, and this by means of the irregular, gaping and loosely-fitting casings and hoods as I saw presented. Botch work of this kind should never be tolerated in any furnace shop. It does not follow that because a tinker may be able to make a tin cup or a joint of stove pipe, that he is also able to make a perfect fitting casing or a hood on a furnace, although to a thorough mechanic, the one is just as easy to make as the other. There are a good many points to be taken into consideration when getting out these fittings for furnaces, which the better or thorough workman sees and acts upon when measuring up a set of furnace castings for the casings and fittings, which are to be made by him. These points the careless and inferior man, in his bungling way, probably would never see, and even when he may by chance stumble upon or become aware of some fault in the construction or design of the furnace he is working on, he, in his dense stupidity, can not find a way out of the difficulty, so that when his part of the work is done it is imperfect. We are all acquainted with this type of workman, and your trained furnace man is kept on pins and needles, shuddering as to the possible blunder his fellow workman may perpetrate. Many and many a piece of incomprehensible stupidity on some simple part of a job has caused endless labor. With such a fellow laborer at one's side it behooveth the thorough furnace man to be continually on his guard. The fact is, that in furnace work of this kind, to do it properly, the workman must be careful, deliberate, precise, and last, but most important, he must have the required amount of skill to do a smooth piece of work after he knows what is really required of him. In a future article I will point out some of the most important objects that must be considered when getting out work of the class alluded to in the foregoing.

Fig. 86 shows by A and B hoods somewhat similar to those given by Fig. 85 in certain parts of their general construction, but differing from them in so far as to be of a more complete design and a far better hood for the purpose. The most important point of difference between this style hood and that shown by Fig. 85 is that this style has a band attached to its bottom end equal in size to the casing ring on which it fits. This band can be either set down or double seamed on the flaring part of the hood. The advantage of a band of this kind on a hood is that it adds to its height, thereby providing for more air space above the furnace. It also makes a neater looking job and a far stronger hood than the styles made

without this added band. B shows a hood with an inverted conical top and a vertical 4″ wide band set down on the same at its lower end. A shows the same kind of a hood, but with a flat top and a 3″ band added on to its upper end. This 3″ band is put on this style hood to enable one to fill the top with sand, in case the collars are taken out at the side of the hood. It will be noticed that the top band has a wire laid in at its top edge which secures stiffness for that edge, while the way this band is fastened to the double seamed top edge of the hood, is shown by Fig. 87. These bands are generally made about from 2½″ to 3″ wide when complete. As ordinarily used for furnace hoods, they are made for utility, but are also often placed on the hoods of room heaters, etc. When these hoods are provided with bands they are often made of highly ornamental patterns, having fancy designs cut out of their sides, or in some cases several beads are swaged around them.

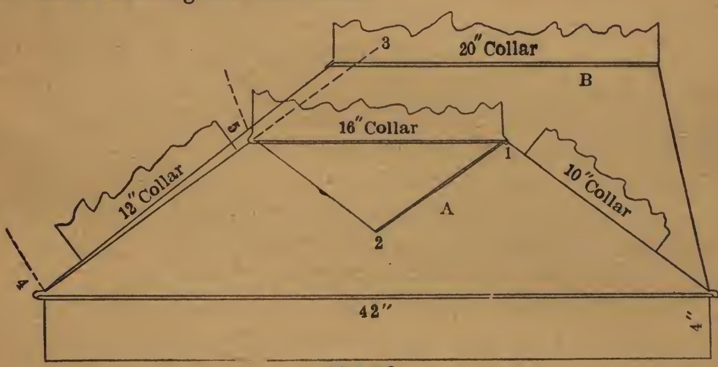


Fig.88

In some instances, where a very fine finish is desired, a polished brass strip is fastened around the outside of this band. This produced a splendid eff ct as in o e instance noted, the casings and the hood were made of Russia iron, the casing also being provided with brass strips of equal width as that of the band around the hood of the heater. To sum up, the styles of hoods as described and shown in Fig. 86 are the most perfect kinds that are commonly used. I may also add that they are the most costly to make. C of Fig. 86 shows the style of hood sometimes used by furnace men, where but a few pipes lead from the furnace top, and also in cases where there is not enough room to put a higher hood in position so as to secure enough elevation as demanded for the proper working of the furnace. As to my own individual choice, I cannot say that I regard it with much favor, but have included the same in this series to make the variety as complete as is consistent with giving a full exposition of all the different kinds of hoods used in actual practice. In some cases, where

there is but one pipe leading to the floor above from a furnace, this style hood does well enough. A far more preferable pitch for a hood is shown by the style as in A of Fig. 88. On this hood are shown three outlets, one in the center, a 16″ collar, a 12″ one on one, and a 10″ one on the other side of the center collar or outlet. The reason why the pitch of this hood is better for the purpose than the hood C of Fig. 86, is that it is steeper and therefore allows the volume of air to have a more easy and rapid flow to the pipe leading upward. The same hood can also be made in another shape, that is, the part from 1 to 2 instead of continuing to an apex, as it would if nothing were cut away as has been done to show where the 16″ collar joins on the hood, may be formed and pressed into the shape as shown by 1 to 2 of A, forming an inverted cone in the center of the hood. This entire top can be made out of one piece of material, or, in other words, can be formed to shape after the complete top is made up into one solid disk of iron laid out in the flat.

To accomplish this proceed as follows: At point 3 as center, use the distance from point 3 to point 4 as radius; describe the required circumference, whatever the case may demand according to the diameter the ring may be, the top is to fit to it with its lower edge. Then from point 3 to point 5 mark off the circular line where the bend or break occurs which will be the highest part of the hood, where it is finally formed to shape as desired. After the disk is cut out as the problem demands, mark or indent a crease along the line 5; after this has been done proceed to form the lesser conical part of this top as desired, but be careful not to bend it too much at once in the beginning. Follow this operation, after the center part has been bent, to some extent, by bending the outer part somewhat in the direction it is desired it should have when finished. Repeat the operation until the whole top is formed to its final shape, then rivet the center seam together and the top of the hood is completed. This hood, if well done, makes a very good, strong and compact shape; it is mainly used by some furnace men for the smaller sized furnaces, or such from which there are not a great many outlets. In laying out the pattern for a top of this kind, care must be taken to leave enough material for the lap of the center seam and also for the laps for the edges which are to be set down or double seamed on the band at its lower edge. In riveting the center seam, have the rivets spaced about from 1″ to $1\frac{1}{4}$″ apart from center to center. Use 10-oz. rivets on 26-gauge iron, head the rivets neatly, and be careful to have the iron lay up well; if the foregoing directions are followed, a first-class job may be expected when making a hood as covered by the foregoing description.

B, of Fig. 88, gives a side view of a hood which has but one outlet at its top. We will assume that the furnace is placed in such a position that the outlet, in order to connect with a vertical pipe, will have to be placed to

one side of the center of the top of the hood. In order to accomplish this with the least trouble and expense the shape as B of Fig. 88 shows is the best shape that could be adopted for the purpose sought. By using this shape top two angles and some fitting in connection therewith, which would be necessary if the collar of the outlet were placed in the center of a regular conical-shaped top, are done away with. This method also insures a straight upward flow of heated air from the furnace underneath. Directions to lay out the required patterns for this shape will be given in full further on.

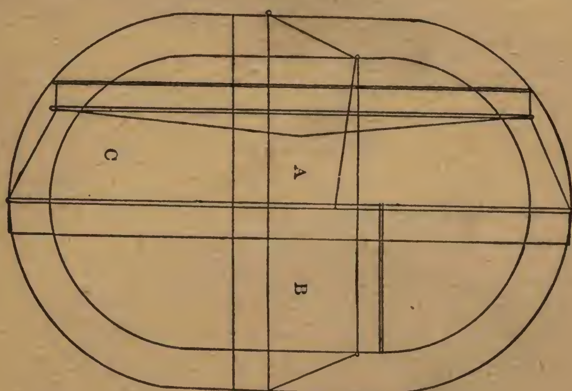


Fig.89.

Fig. 89 shows the shapes of two styles of hoods for oval-cased furnaces. A gives a style without a band to its upper part but with a dished top, while B gives a flat top hood with a rim around it. C is a side view o B. Both styles have a band at the lower end of the tapering part which fits to the casing ring. These two styles are precisely the same as the hoods shown by A and B of Fig. 86, with this difference, that a flat part has been added to each side in the center; that is, if a circle be cut into two equal parts and these two parts be moved apart and two straight pieces be inserted, one on each side, both of equal length and having the same inclination as the circular parts have. The manner of making a hood of this kind is the same as the method employed in getting out the ordinary common round hood; the flat sides are to be added as a matter of course to make the hood conform to the shape as the design demands. This style of hood is used by many manufacturers where a furnace has a radiator attached to it and the same is cased or portable, the elongation of the shape of the casing being made to conform to the circumstances as the occasion demands. Fig 90 gives a plan and a side view of one of the largest size hoods made for furnaces. These are made principally for large wood burn-

ing furnaces used to a great extent in the Northwest where wood is cheap and coal correspondingly dear. Fig. 91 shows a hood somewhat similar to the one shown by Fig 90, still differing in its general shape, and also that Fig. 90 shows a top rim while Fig 91 has none. I will give a method to lay out the shape or the pattern for these hoods further on. The dimensions for some sizes of these hoods are 6′ long by 40″ wide and in some cases 18″ high. These kinds of furnaces are generally used in the same section of the country for large buildings, such as school and court-houses, churches, etc.

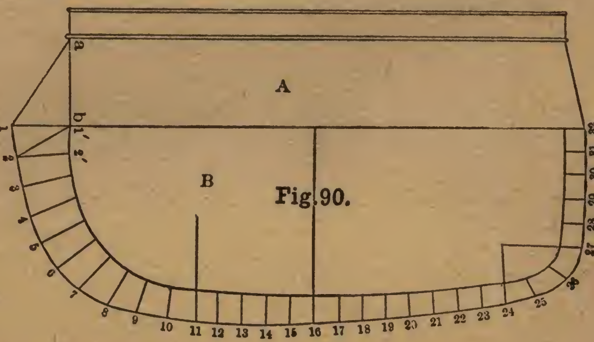


Fig. 90.

Having described the leading and most used styles and kinds of furnace hoods in use throughout the country I will next give some methods to lay out the patterns for them. Fig. 92 at A gives the plan of a common conical-shaped envelope of a hood which is the same as B of Fig 85. B of Fig 92 gives the side elevation of the plan A of the same figure. I will first discuss the ordinary method used in finding the pattern for the envelope of a frustum of a cone, which is the shape of a common hood, as B of Fig. 85 shows. The first step to take is to draw the full side elevation the outlines of which B, from 1 to 2 and from 3 to 4, give. Connect point 2 to 1 and continue this line indefinitely; do the same with points 4 to 3, and also extend the line connecting the two last-mentioned points until it intersects the line 2 to 1, which it does at the apex at C. Where these two lines form a junction, drop a line midway between them, as the line C to K shows. Having drawn the line C to K it will be found, if drawn as directed, that at the point where it cuts the line 2 to 4 it is at right angles to the same, and, as a consequence, is precisely in the center of B of Fig. 92. Using the point C as center, set the compasses at point 1; this distance gives the length of the radius for the curve demanded for the top curve from points 1 to 3. The same operation from C to point 2 gives the radius for the bottom curve as from point 2 to point 4. Draw the curve 2 to 4 with the radius from C to point 2, and extend it until the length of this

curved line is equal to the circumference of a circle whose diameter is equal to the straight line 2 to 4 of B. This gives the correct sweep that the curve 2 to 4 must have in order to produce the bottom line of a frustum of a cone such as B of Fig. 92 calls for.

A similar operation has to be performed in order to produce the correct line for the top line of the same figure, the radius for this being from C to point 1. Commencing from point 1, the curve as drawn connecting with point 2 and continued until its proper length is developed, which is the circumference of a circle whose diameter is equal to the length of the straight line connecting the points 1 and 3 of B. Connect the points where the two curves as described terminate with the center point C by a straight line, and a complete pattern of an envelope of a frustum of a cone is the result, as demanded by the side elevation B of Fig. 92. This gives a pattern in one piece and is the strictly geometrical method to obtain it. may add that it is absolutely correct. The two concentric circles of A give the correct relative positions of both the top and bottom ends of this frustum after the pattern has been formed to the shape as demanded by B.

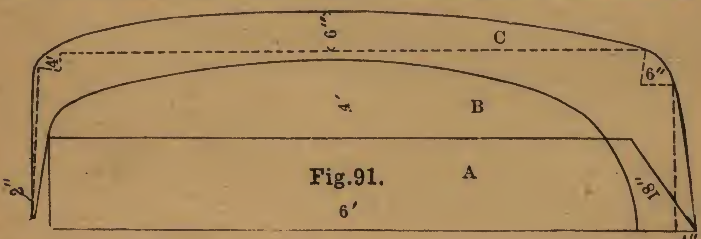


Fig.91.

In the foregoing no allowance has been made for laps or joints of any kind whatever; these must be provided for when laying out the patterns. I will assume that in the problem as described a hood is wanted whose bottom diameter is to be 40″; at the top it is to be 30″, which gives it 5″ slant on the sides, and it is to be 14″ inches high measured on the slant height or on the side when finished. Draw a side elevation as the figures call for; find the center point C as described; draw the top and bottom curves as directed and make the length of the bottom curve $314 \times 40'' = 10'\ 5\frac{6}{10}''$ and as a matter of course it follows that the top curve will be $314 \times 30 = 7'10\frac{2}{10}''$ long. These deductions are drawn as if the entire envelope was made out of one piece, this being impossible because the sheets of iron from which the work is to be made are not large enough, and even if they were to made an entire envelope of a hood out of one piece would cut the iron to too much waste; this reason, and also the extra cost, makes it imperative that the envelope be made out of smaller pieces or sections. The most suitable and best adapted size of sheets for nearly all sizes and kinds of

hoods are those that are 30″ wide. The pattern laid crossways on the sheets and each section made as long as the sheet will possibly admit, is the best way to cut them out. This makes it necessary to allow for a lap at one end of each section, so that when the entire hood is formed and jointed toge her it then measures as given in the foregoing, namely: at its bottom edge 10′ $5\frac{6}{10}$″ and at the top 7′ $10\frac{2}{10}$″. Extra allowance must be made at the top and also at the bottom for whatever kind of lock, fastening or double seam it is desired to use to fasten the conical part of the hood to the top and bottom parts with which it connects.

Some furnace men use a lock seam to fasten together the ends of the sections of which the conical part of a hood is composed. This I do not consider a good way, because if it should happen that an opening must be cut in the side of the hood and it happens to be where there is such a seam, it makes it very awkward, unhandy and difficult to cut a hole in that place. The seam in nearly all cases is liable to become unjointed and also for the reason that a smooth, firm connection cannot be made with the outlet collar if it must be joined in position over the clumsy double-seamed lock, which this method of joining the sections together leaves at the place where the joint is so made. The neater, better-appearing and stronger joints are those that are riveted together, there being no possible chance for them to come apart if properly done no matter how much rough usage the hood may have to stand in handling while shipping and transporting from the shop to where it is finally put up on the furnace. I would advise to rivet all these joints as described, spacing the rivets $1\frac{1}{4}$″ apart from center to center and using no heavier rivets than from 10 oz. to 1 lb. for even the heaviest material used for making hoods. Allow a lap of $\frac{3}{4}$″ only for the joints; have the plates lay up snug and even. Do not draw the rivets through the iron but have well-matched holes punched through the plates before attempting to join them together. In short, do a good job throughout this part, and be sure to make the hood tight and sound throughout as in no part of the casing of a furnace is it more necessary to do first-class work than on the hood.

There are several modes used in furnace shops to prepare the sides or conical parts of hoods for the tops or covers to be put on them. In some shops it is the custom to join the sections together, either lock-seamed or riveted, and then the workman, with the assistance of a helper, turns the required burr or edge on the top end as required for the double-seaming on the top. The same operation is also performed with the bottom edge of the conical part, if the hood is to have a band or is of the style which has a band attached to the bottom part of the hood. This way of getting out the hood I regard as the most cumbersome, tiresome and time-wasting mode that could be adopted to attain the desired result. A far easier, quicker and handier method is to turn all the required edges both on the

top and bottom ends of each section complete before they are joined together at all. Form the sections after all edges have been turned to the

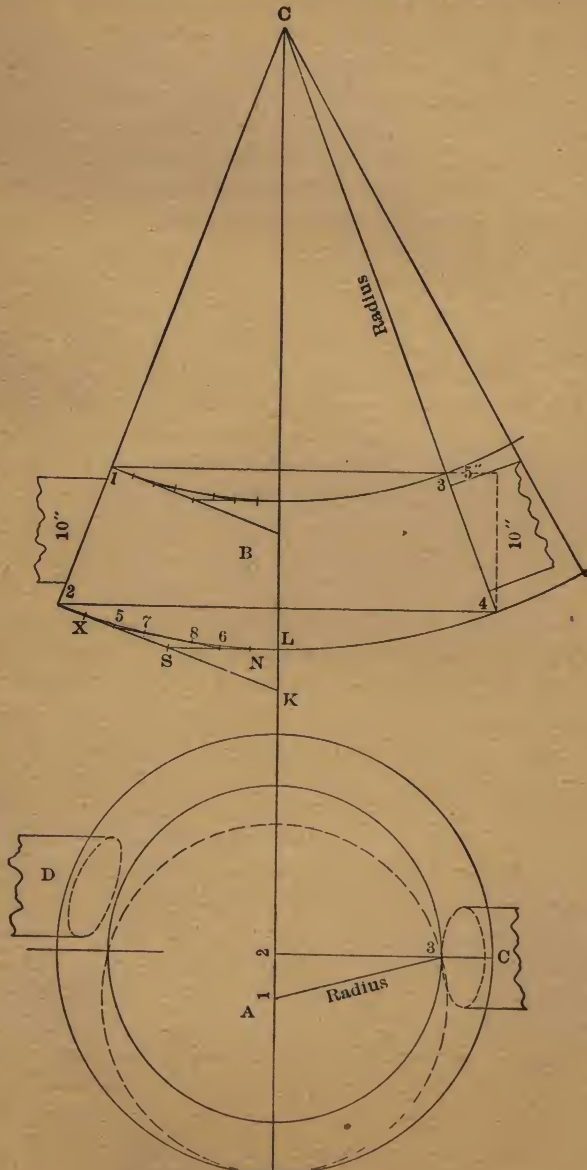


Fig.92

required shape as demanded to insure their proper fitting. Then it becomes

an easy matter for one man alone to rivet the up and down seams or laps, thus saving the services of an extra helper and also by this method producing a far neater and better job than the other way, and also saving time by reason of the work being simplified and easier joined together.

It may not be out of place at this occasion to direct the attention of the student to one important fact which most workmen do not seem to understand, namely, that a pattern which is laid out and cut for a certain size hood, I will say a 40″ hood, will not answer to lay out the parts with of, say, a 44″ or 48″ hood, even if the hoods are all alike as to the angle that the sides incline toward the center. This fact can be readily demonstrated by any one who cares to lay out the correct pattern for each size hood above mentioned. Do this as directed and when the three different patterns are laid out and cut as they should be, compare them one with the other by placing them one on the other and the very marked difference will at once be seen. I have been in shops where some so called furnace-men used one pattern for half a dozen different sizes of hoods, with the never-failing result that when the work was done the hoods that were gotten out but for which the pattern was not just right, were botched both in their fitting and also their general appearance. The proper way to do is to make a pattern for each size hood that is to be made; a few minutes devoted to the proper laying out of the correct patterns often saves a good deal of trouble afterward.

The plan A of Fig. 92 also shows how to get the radius for the inverted conical top for a hood. If the top is flat, all that is needed is to cut the disk to the size as the top end of the hood measures and add enough material to allow for the edges for the double seam which joins the top and sides together. But where the top has a downward pitch, as from point 2 to 1 of A, the point 1 is used as center and the point 3 as the starting point and also as the other end of the radius. Describe the circle as is shown by the dotted line or circle of A; add to this enough material for the edge for double seam and the correct outline is obtained. A quick way to get the cover to fit, that is, to get the correct points where to cut out the gore piece, is the following: Turn the edge for double seaming the cover to the body of the hood, then cut on, from any point of the outline of the disk, a straight line to the center of the disk or point 1; place the disk on the hood and press the disk downward until the edge which has been turned on the edge of the disk or cover catches firmly on the edge which has been turned on the body at the top end of the same. While the top is held in this position mark off where the overlapping occurs on the top disk. Now take the cover off, allow one inch for lap, cut out what is left of the gore and then rivet the two edges together lapped as directed. This method is the quickest way that the desired result can be obtained and has this point

to recommend it that it assures a perfect fit every time. When the top of the hood has been fastened to the body and is pinned down and ready for double seaming, the most convenient, easiest handled and best adapted stake to use to hold on with to double seam these parts together is an ordinary, medium sized sad-iron. I have never come across anything that serves the purpose more satisfactorily than an old flat-iron. Having once used one for this purpose no one would again attempt to use the awkward dragging and inconvenient stake fastened to the bench with which to double seam furnace hoods.

Having given a full exposition how to get out hood patterns by the strict geometrical or long method, I will give a shorter way to attain the same result. A hood if made by this method, although it may not be quite as precise as if it had been made by the first process given, is yet accurate enough to do good work and close enough to be so near perfect that scarcely any difference can be detected with the unaided eye alone in the general shape of the hood when completed. The method is as follows: Having drawn a side elevation as B of Fig. 92 shows, bounded by the lines connecting the points 1 to 3 and 4 to 2 and from 2 to 1, set the square on line 1 to 2; from point 2 draw a line at right angles to line 1 to 2, which cuts the center line at point K. Divide the line 2 to K into two equal parts as at S. Draw the line S to L parallel to line 2 to 4. The point 4 on the center line is to be equi-distant from point K and also from the line 2 to 4. Divide the line 2 to L in two parts and also the line 2 to S.

Connect these two last found points by a line as is shown by the line from the points 5 to 6; subdivide this line into four equal parts and mark off the two end divisions thus found, as is shown by the points 7 and 8. Then divide the line from point 2 to 5 into two equal parts as is shown by point X; connect point X with point 7 by a line. Divide the line 6 to L into two parts as shown by point N; connect points N and 8 by a line. These subdivided lines very nearly show the correct curve of the bottom edge of the frustum of a cone as is demanded by the drawing. The same operation is to be done to find the curve for the upper end of the hood. This process of dividing these lines can, if so desired, be carried to as minute a degree as suits the one getting out the pattern. The more steps that are taken the more perfect the curve becomes, but for all practical purposes the steps as shown are far enough to give a nearly correct pattern. In order to get the curve on the other side of the center line the same process has to be gone over for that part. I often use this method when in a hurry to get a job out, and it comes very handy when the sweep or radius is too long to be conveniently used to get out the required patterns.

The plan A, Fig. 92, at its outer edge also shows two starters or outlet collars as they appear from that point of view. One is a straight-out

collar while the other is of the kind called a right or left-hand collar. Full instructions how to make these, and how the patterns for them are made will be given hereafter. The usual pitch or angle of inclination from a vertical line for the sides or body of the furnace hoods is from 3″ to 5″ to the foot. Ordinarily it is 4″ from the vertical, as they are made in most shops. Fig. 93 gives the various angles, and also the degrees which a pipe

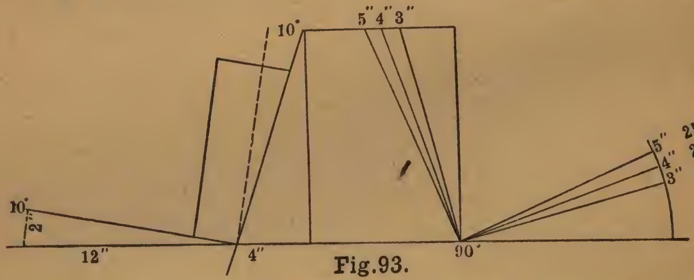


Fig. 93.

assumes from a horizontal position if it is placed at right-angles or 90° to the side of a hood. One side of Fig. 93 shows a collar put on at an angle of 10° less than 90° and as a consequence it only has a rise of 10° to the foot, as I have shown by the drawing. This angle, which gives the pipe a rise of 2″ to the foot from the horizontal, is very often used in getting out a permanent set of patterns for hood collars. Some firms use no other than straight out collars while others again use collars that have a pitch of from 3″ to 5″ to the foot from the horizontal. Fig. 94 shows a style of collar or

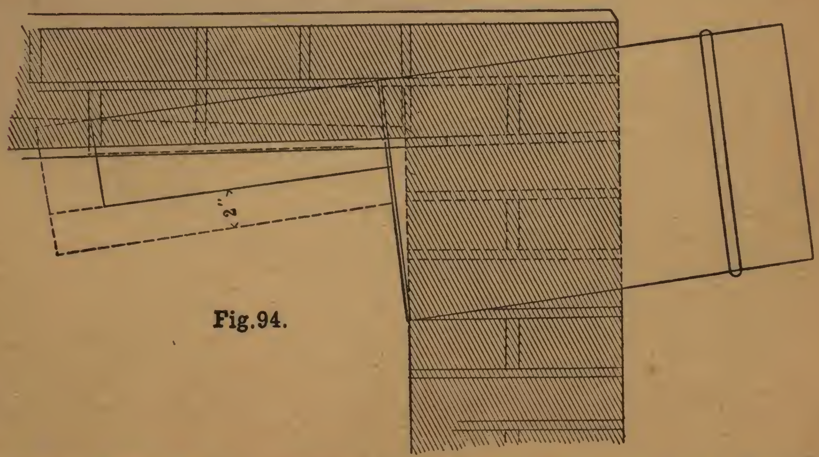


Fig. 94.

starter for brick-set furnaces. The style as shown is a favorite with many furnace-men. They are made of one full joint of 20″ in length and a piece of 14″ pipe, but of only half the circumference of a full

joint. They are usually bricked into a furnace in the manner shown. The edges that come below the bottom of the top of the furnace or hot air chamber are bent out sideways and trimmed so as to fit between the tee irons or the supporting bars. This style of starter makes one of the best kinds in use; in fact, I would advise to use no other for brick set work. The angle at which they are set can of course be suited to accommodate the collar for any angle. Then this shape, at once both provides for an outlet from the top and also at the upper edge of the vertical wall. It will also be noticed that it reaches well back into the body of the furnace, providing as large an area to get its supply of warm air from the air chamber as could possibly be obtained for a starter of any kind made. Then it is cheap and easily made and meets every requirement that would be demanded of a first-class brick-set furnace-pipe starter. In order to finish the subject of portable furnace hoods I will give a simple method to lay out the patterns for the hood B of Fig. 88. The pattern for this shape can easily be developed by triangulation; that is, by using several sets of triangles to get the actual distances, heights, etc; also the correct shape of the envelope. The one paramount aim that the student must bear in mind when solving pattern problems by the various modes of triangulation is, that it is absolutely necessary that in the very outset he begins with a correct starting point, and that each succeeding step is precisely as it should be. The work of drawing the patterns must be done correctly and with the utmost care. This is about all that there is to this much exploited system of laying out patterns. The simple rules and fundamental principles upon which this system is based are in themselves so easily acquired that it is surprising to find that they are not more generally used by mechanics in the trade throughout the country.

The first step to take in laying out this pattern is to draw a correct side elevation, as A of Fig. 95 shows, of this hood, which is from the point 1 to 9 for base line, from 1 to C C and from 9 to 9′ for the lines of the sides or boundary lines, of the body and from C C to 9 for the top line. Then draw the two semicircles B and C for half of the top and bottom ends. Divide these into any equal number of parts, as has been done in this case, each into eight equal parts, as shown by the numerals 1 to 9 in both instances. Connect the points thus found by solid lines as shown in the plan B and C between the corresponding numerals as 1 to 1′, 2 to 2′, etc. Then connect the points as the numerals 1′ to 2, 2′ to 3, etc., shown by dotted lines. The next step is to construct the triangles. Set A of Fig. 95, corresponding to the solid lines and set B to those of the dotted lines. Drop the line from point C C to the point 1′ on line 1 to 9″ at right angles to this last line. The line thus drawn gives the actual height of the altitude, for the lines

which are the hypothenuse of each angle used in this problem, for the set A or solid lines.

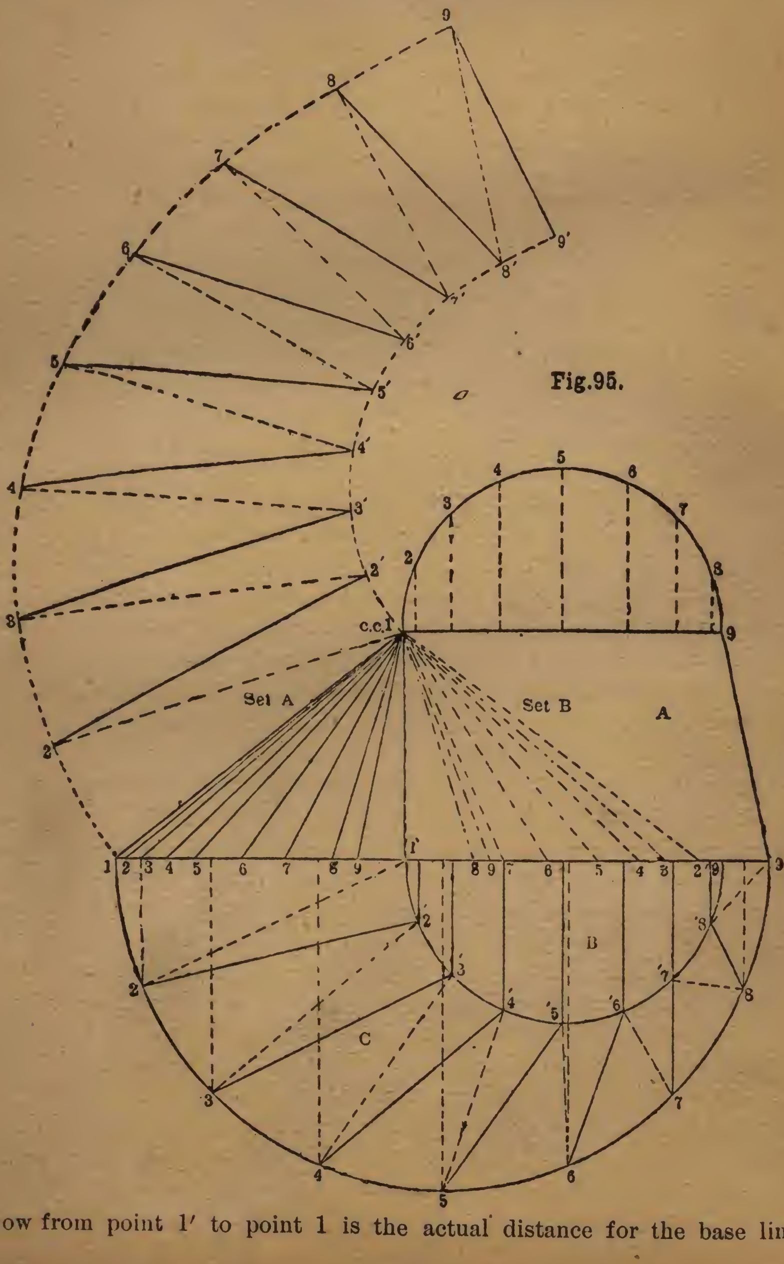


Fig.95.

Now from point 1′ to point 1 is the actual distance for the base line

for the stretch-out line, or actual length of the hypothenuse, or, in other words, it is the longest and greatest width of the envelope which is to be laid out. Next, transfer the distance from point 2′ to 2 on the line from point 1′ to point 2 on the line 1 to 9″. Do the same for each succeeding solid line as is shown in the drawing where 3′ to 3 of C is transferred to the base line from point 1 to 3, etc. After all these distances are so transferred and all their respective points are established as shown by the numerals 1, 2, 3, 4, etc., to 9, on line 1 to 1′, connect the points thus found by solid lines with the apex at C C and this completes the set A or solid triangles. A similar operation is to be followed with the set B or dotted lines of triangles. The length of the first dotted line which is to be trans-

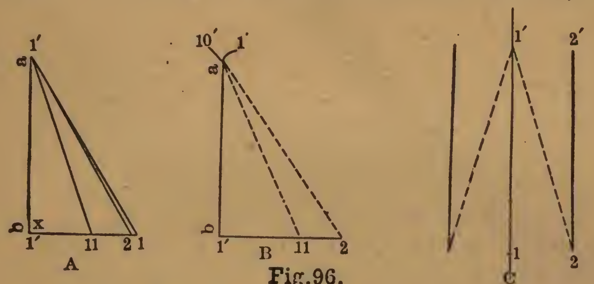


Fig.96.

ferred is that of the line from point 1′ to 2 and is so done on the line 1 to 9″ from point 1′ to point 2 on the same line. Then from point 2 thus established a dotted line is drawn connecting it with the apex point at C C. A similar operation is gone over with all the rest of the dotted lines as is shown on the base line of the set B of triangles, the dotted line 2′ to 3 corresponding to the distance from point 1′ to point 3 on the base line of the set B, and so on for all the rest of this set. Connect all the points thus found for the set B. When this is done we can next proceed to lay out the pattern for the envelope for the shape under consideration. Right here is where the most care must be taken to get all the steps absolutely correct, in order to get the exact pattern, for the least little slip will throw the entire pattern off from its true development. At this stage it is mainly a matter of how careful one is in doing each step right that the correct result depends on. The length and position of the longest solid line, which is also the center line of the pattern, is given by the line 1 to C C. Place the compasses at point 1; strike an arc equal in distance away from point 1 as 1 is away from point 2 of the outer circle of C. Then set the dividers the length from point C C to number 2 of set B or the dotted triangles. Set one point of the dividers at C C and strike an arc intersecting the arc which is the distance from point 1 as 1 to 2 of the plan C. This establishes the position of the point 2 of the pattern. Next, transfer the dis-

tance as from point 1′ to 2″ of B to the inner curve of the pattern from point C C to 2′ of the same. Then transfer the length of the solid line C C to 2 of the set A of the solid line of triangles, from point 2 of the pattern to where it intersects or cuts the arc as found or drawn at 2′ of the inner curve of the pattern. This establishes the correct position of point 2′. The same general mode of deducing and establishing all the remaining lines and points is to be followed for the rest of the pattern throughout. To repeat each would be superfluous. After all the points are found that are necessary to establish the curves for the pattern, the same may be connected by a free hand line drawn from point to point as has been done for the pattern in the drawing. The pattern as shown is only one half of the entire envelope, the other part being the exact reverse duplicate of the same. Allow for all laps and all edges for double seaming and connections that may be necessary for the proper putting together of this hood.

To develop the patterns for the shapes as the hoods, Figs. 90 and 91 have, the same general rules, methods and operations are necessary, the only difference between these shapes and Fig. 88, being that they are rather larger and of a somewhat different form. The student may, if he so desires, divide the sets of triangles into three or even four divisions for the larger shapes, there being in Fig. 90 thirty different solid line angles, as I have divided them, and thirty-one dotted line angles. For convenience, and to be easier to get over the entire lot, they can be put in such shape that no possible confusion will arise if the hint given is acted upon. In Fig. 96 I have given the starting points to lay out the envelope for Fig. 90. These are drawn to the scale double the size shown by Fig. 90. A is the commencement of the first set of solid line angles and B of the dotted line triangles. C is the commencement of the development of the envelope, or the pattern, and is so arranged that the same can be laid out, commencing with the center line, to the right and left-hand way at one and the same time, if so desired.

Fig. 97 gives the method to lay out a vertical collar on a hood as C of the Fig. 86 shows. The first step to take is to draw a side elevation of the required hood and the position that the collar has to have on the same, as is shown from points A B to C. Next draw the horizontal line of the collar as from 7 to 1. Draw the semi-circle as shown; divide this into any number of equal parts. In this case I have divided it into six parts. Drop lines to the line A, C of the hood as shown from the points, as developed by reason of the foregoing division of the semi-circle. Connect the point 1 to 1′ by a solid line.

The next step is to draw a section of the plan of the hood, as shown from B C, to D in the drawing. Draw one-half of the required circles of

the plan in its proper relative position as the side elevation as drawn demands for it to be on the plan; all this is fully shown on the plan. Divide this half into the same number of equal parts, as has been done in the elevation. Drop lines from the points thus found to the line B to D and at right-angles to the same, as has been done and is shown at the

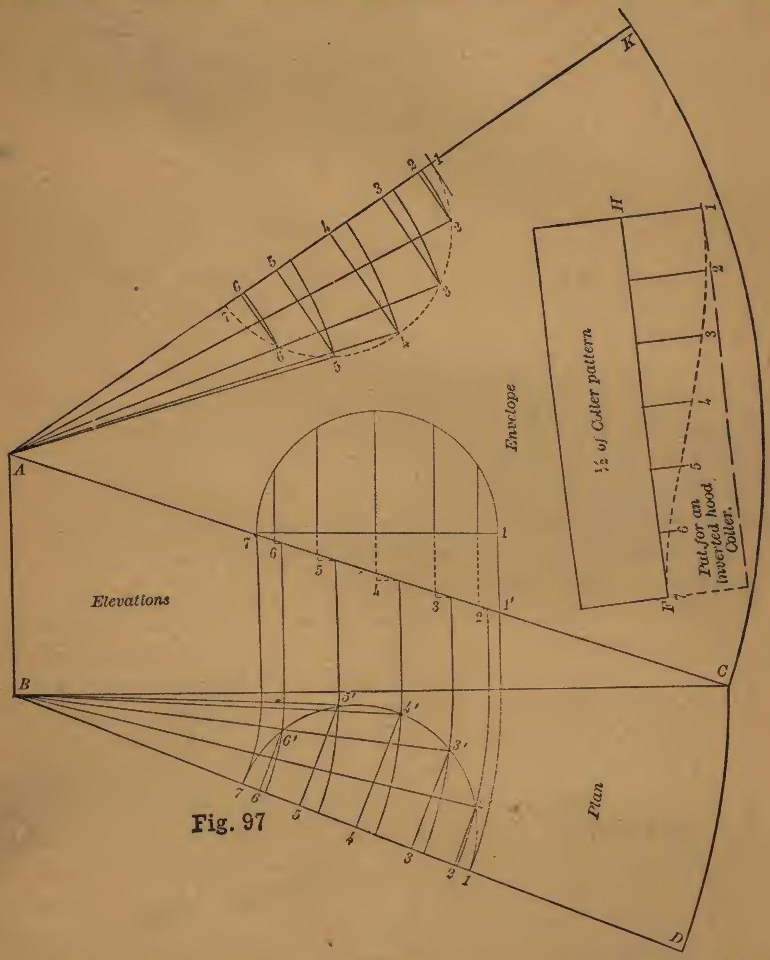


Fig. 97

points by the numerals 1 to 7 where they connect with the line B to D. From B as center draw the curves as shown using the points 7, 6′ 5′ 4′ 3′ 2′ and 1 for the extreme length for each radius for the respective curves. Where these curves cut the line B to C, continue with straight lines at right-angles to line B to C until they intersect or cut the line A to

C. At the points where these lines cut the line A to C, draw lines at right-angles from them and connect them with the dotted lines which are extended down below the line A to C as shown in the drawing, by the numerals 7 to 1 of the elevation. The points thus found, establish the correct length and position, and give the data for the development of all the lines for the required pattern for the collar.

To develop the latter, draw a line equal in length to the circumference of the collar; divide this into an equal number of equal parts. From points thus found, draw lines at right-angles to the same, as has been done from line F to H for one-half of the entire pattern, as the numerals 7 to 1 show. At the lines thus drawn mark off their respective lengths, as the lengths allowed for them, by the lines from line 7 to 1 to the points 7, 6, 5, 4, 3, 2, 1, of the dotted lines of the side elevation of the collars. After these distances are all transferred and the actual lengths of the lines on the pattern are marked, draw a free-hand line connecting these points as is shown in one-half of the pattern; duplicate the other half and the pattern is finished. For an inverted hood collar the pattern is simply the reverse of that for the cone just described, and is so shown and marked on the drawing. For the hole that is to be cut out of the hood the drawing gives all the particulars as on the line A to K. The section A, C to K, as shown, is drawn with a radius from A to C, which is the correct stretch-out for the envelope for the top of the hood itself. The hood being on an incline from point A to the lower edge, as the curve C to K, it naturally follows that the shape of the cylinder resolves itself into an oval on the envelope of the cone, that is, the line of contact of the cylinder with the hood, the longest axis of the oval being on line A to K from points 7 to 1. All the intermediate points from point 6 to 2 are in precisely the same relative positions from and to each other as those points shown beneath the line A to C of the elevation of the hood. The lengths of the lines drawn at right-angles from the line A to K are the same as the corresponding lines shown in the semi-circle of the elevation. The positions of all the points thus established give the actual and correct outline for the opening required on this hood for the collar described. Connect these points with a free-hand line and the pattern is complete as far as its laying out is concerned for this hood and a vertical collar for the same. Fig. 98 shows a method to lay out a straight-out collar on to an ordinary flaring hood as Fig. 92 gives at C. The first step to be taken is to draw a complete and accurate side elevation of the hood and also of the desired collar or starter, which has been done in this case above the base line A to B. The entire outline of the elevation of the hood is given within the points from A to B for base line; from B to A′ gives the slant height of the hood, from A′ to B′ gives

one-half of the top line of the entire hood, and from B′ to A is the center line of the same. From point 1 to 7 gives the length from the top to the bottom of the collar nearest to the hood. From 7 to S and 1 to S′ gives

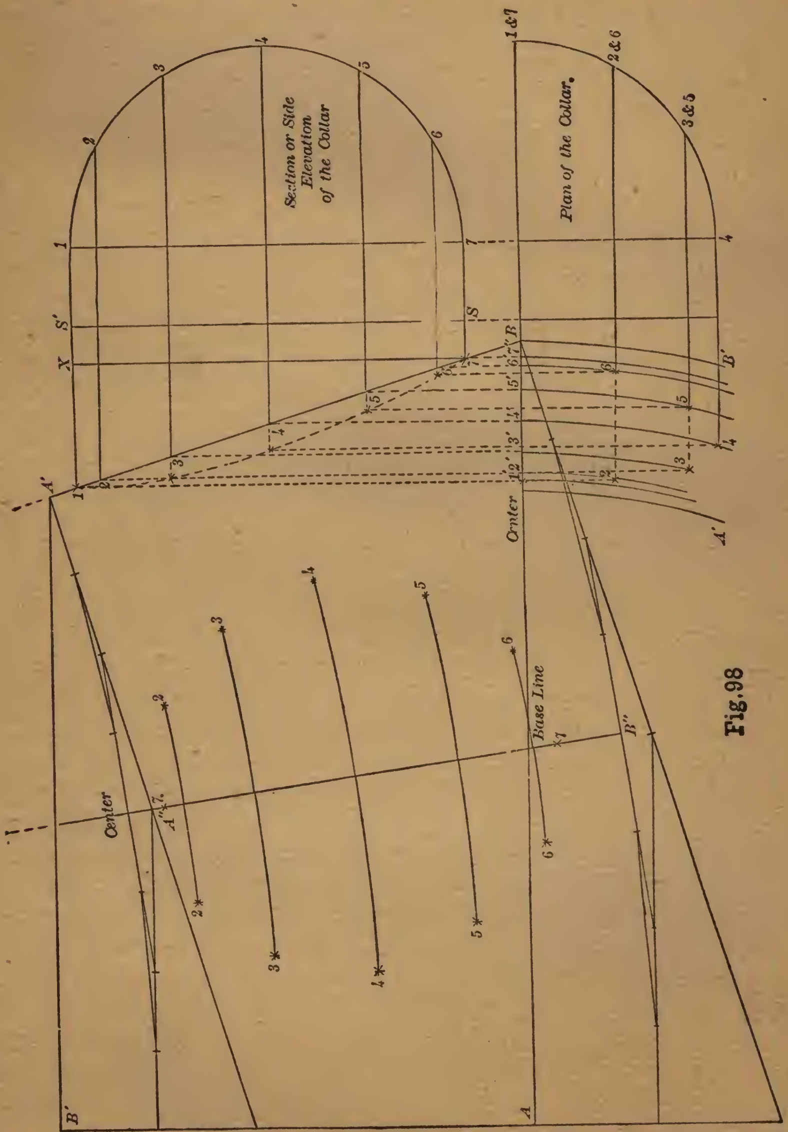


Fig. 98

the top and bottom outlines. The semi circle 1 to 7 gives one half of the collar. This is divided into six equal parts, with lines carried parallel to

the line 1 to 7 of the hood as the drawing shows. It will be observed that the envelope of the hood has been laid out by the method described in Fig. 92, and for that matter this method has been made use of in its practical application for all the rest of the hoods following and described in this article. The line from A″ to B″ is merely drawn as a center line to assist in the ready laying out of the shape of the hole that is to be cut out of the hood for the opening to which the collar is to be joined. Directly underneath the elevation is the drawing for the plan. The curves as shown by 1 to A′ and from B to B′ are the extreme outlines of both the top and the bottom of the hood, as they appear in the plan. Adjoining this is one-quarter of the collar no more being necessary for the practical laying out of this problem. This part is also connected to the plan part of the hood by lines, as line 1 and also 7, 2 and 6, 3 and 5 and also 4. Some of the lines, although appearing only as one line, as a matter of fact represent two lines, they both being in the same vertical plane but referring to the elevation lie in different altitudes or horizontal planes. This part of the needed preliminary work done, we may now proceed to take the first step following for this problem.

All the lines having been carried to the line A′ to B in the elevation of the collar, commence at the lowest point where the line 7 cuts the line A′ to B and drop a line from that point to the base line to 7″. Do the same with all the rest of the lines, as lines 6, 5, 4, 3, 2, and 1 show which is the highest point. These lines are shown in the drawing by long dashes and are all shown at their lowest point of termination on the base line by the numerals 1′ to 7″. Now taking the point A of the base line as center, draw the curves as shown at any indefinite length but commencing at the numerals as shown on the base line A to B, these curves being the continuation of the lines above them and also showing the actual position of the planes (that are cut horizontally into or through the hood) from a plan view of the same. The next step is to extend the lines of the plan of the collar far enough into the body of the drawing of the plan of the hood, so that they cut or intersect the curves that are numbered to correspond to them, as the line 4 extends to the curve 4. The line 3 and 5 extends for 3 to curve 3 and for 5 only to curve 5; all the rest of the lines are treated in the same manner and connected to their respective curves. After this is done draw lines from the various points of intersection thus found, and extend them upward far enough so that their upper points of termination line in a plane horizontally to the respective lines, numbered the same as the lines just drawn, and connect them with horizontal lines as the drawings show. The upward lines as last described are all shown in the drawings by dotted lines. Where these lines as described meet and

where the points of intersection occur in the plan as the drawing gives, is the outline of the line of intersection of the collar with the hood, or in other words, the collar joins or cuts through its side on a line connecting the points as found from this point of view or plan. Then where the vertical dotted lines of the elevation connect, gives the points through which the collar cuts the elevation or side view of the hood. The dotted lines as shown in the elevation give the actual line of contact at the junction of the collar and hood. This gives us all the necessary data to lay out the pattern for the hood and also to lay out the opening in the hood.

To lay out the opening draw the curves, as shown in the envelope of the hood, intersecting the center line as shown. The distance down that the first point on it is to be, from the top curve of the envelope, is the same as the distance from point A′ to 1 on line A′ to B of the elevation; for curve 2 take the distance from point A′ to 2 on line A′ to B, and so on for all the rest of the curves that are shown. All these curves are to have the same center point for radius as the envelope itself would have if it were developed by that method; at any rate the curves must have their correct required radius, so that they will develop when the envelope is formed to shape, the outlines, or cutting outlines of the horizontal planes, to the vertical axis of the hood, or the frustum of the cone. As the center line of the hood miters and is joined by the center line of the collar, and both sides are alike, the respective distances can be taken from the drawings of one-half of the opening alone, which in this case has been done. To do this for the opening, transfer the distances as shown by the points 2, 3, 4, 5 and 6 of the plan, from the center line or base line A to B. As the points 7 and 1 are located directly on the center line no curves are drawn for them, but for the curve 2 take the distance on the curve 2 of the plan from the

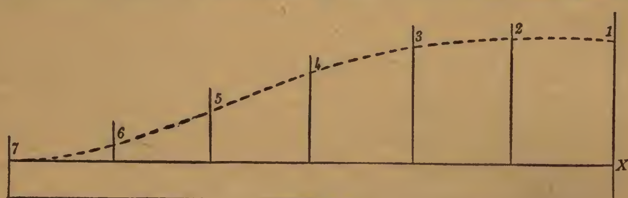


Fig. 99

base line A to B to the point 2 on this curve and transfer the distance so found to the curve 2 of the envelope to each side of the center line, and the two points 2, 2, are established. The same operation is to be performed for all the rest of the curves, and the distances to be transferred. When this is done the entire opening for the collar on this hood is completed, as as far as the laying out part is concerned. To lay out the pattern for the

collar for which one-half of the entire pattern is shown by Fig. 99, proceed as follows: Draw the entire stretch out as demanded; divide this into twice

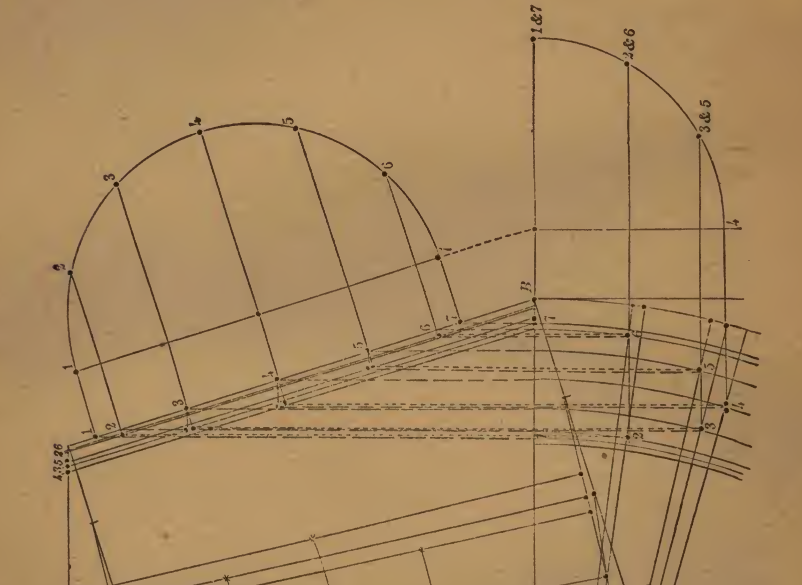


Fig.100

as many equal parts as one-half of the entire collar is divided into, which in this case is twelve. Six parts being demanded for one-half as Fig. 99 gives, I will only show so much in this case, the other half being an exact

duplicate of this part, only that it is on the reverse side. Draw the line 7 to X as shown; on this erect the lines at right angles, which are the division lines as found for the six equal parts that the stretch-out has been divided into for this half. Now transpose the distance from point X to 1 of the topmost line of the side elevation of the collar to the line X, 1 of the pattern. For the line 2 transpose the distance contained in the line 2 between line X to 7 to the curve as shown in the elevation to the line 2 of the pattern. Do the same for all the rest of the lines until the pattern is complete. Then connect the points thus found, as has been done by the dotted line in the pattern. This completes one-half of the pattern. The distances to be transposed are from the line X to point 7, and are bounded on their other end by the curve 1 to 7, the intermediate lines 2 to 6 being the lengths that are to be duplicated on the pattern, each one to its respective correspondingly numbered line. This completes the entire patterns in this problem. The next problem is in every detail similar to the preceding one, with this exception: that the collar is placed at right-angles to the face of the side of the hood, while that of the Fig. 98 is placed and fitted on a horizontal plane, or straighout. For Fig. 100, draw all the elevations and plans as has been done for Fig. 98. When this has been done drop the lines 1 to 7 to the base line A to B, from the side elevation, connecting lines in the manner as shown in the problem Fig. 98. Connect the bottom ends with the curves as shown. Then extend the lines of the plan part of the collar to their respective curves, and erect the upright lines, extending to a level with the points from where they were begun by lines as shown in the drawings by long dashes. At the points where last named lines intersect the short horizontal lines, draw lines, using the center point or apex of the cone of which the frustum is a part, as a starting point or guide, and when drawn so that they cut the intersecting points as found, continue the same

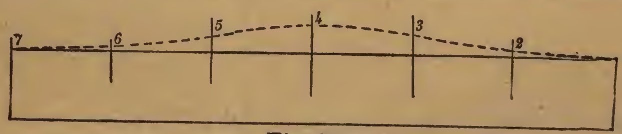


Fig. 101

to the base line A to B. This operation is shown in the drawing. Each one of these lines is numbered at the top end; these numerals correspond to the respective lines to which these lines relate. This done, extend the lines of the side elevation of the collar until they intersect the lines last drawn. From the points of intersection thus found, drop lines to the plan lines from which the first set of lines were erected. At the new or last points found, the correct lines of junction of the collar and the hood occur, and at the upper ends of these same lines the line of junction of the collar

with the hood is established. These last found and developed lines are shown in the drawing by small dotted lines. The method of obtaining the outline of the opening in the hood is the same as was used for that of Fig.

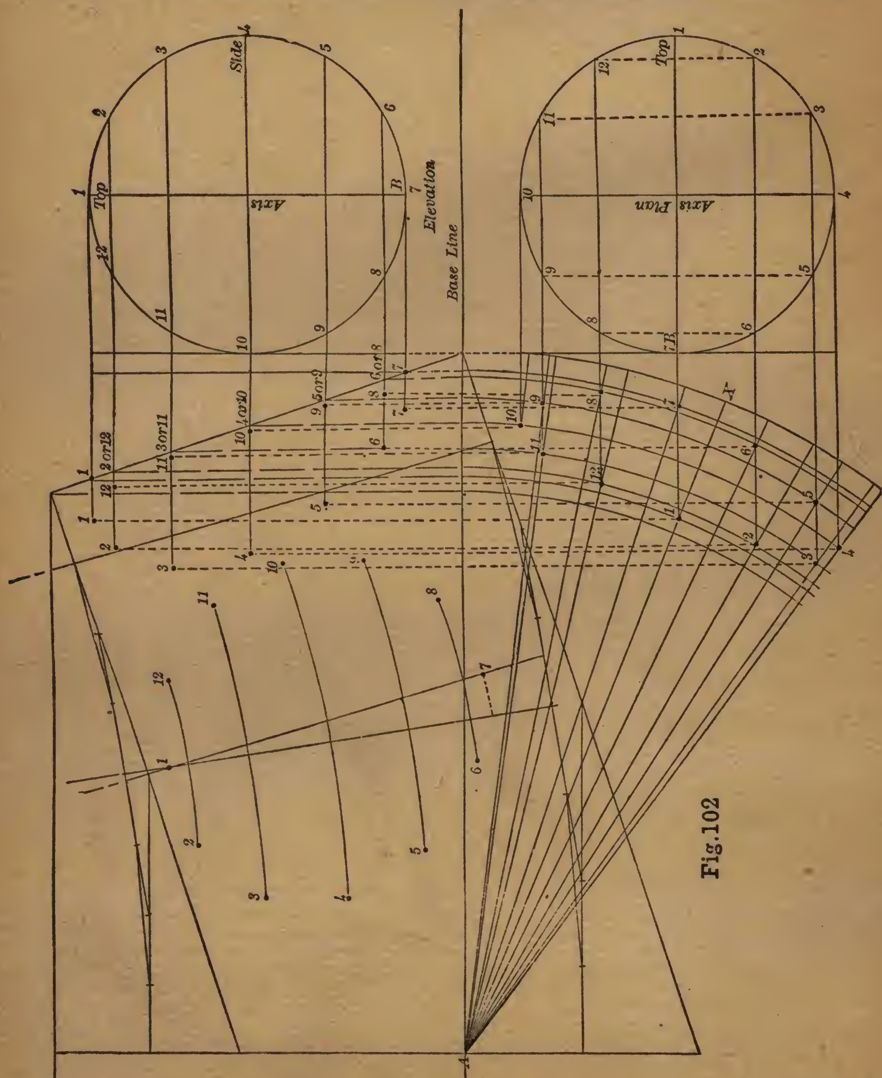


Fig.102

98, as is also the method to be used to develop the pattern for the collar in Fig. 101, which is the same as was used for the collar of Fig. 99. Fig. 101 gives one-half of the entire collar developed in this problem. In the

preceding problems the collars treated on were what are called by furnace men straight-out collars. One was a horizontal one and the other was on a rise. In Figs. 102 and 104 I will give the methods to lay out what are commonly called right and left collars. Fig. 102 shows a straightout. or a horizontal collar, located on one side of the center line of the hood.

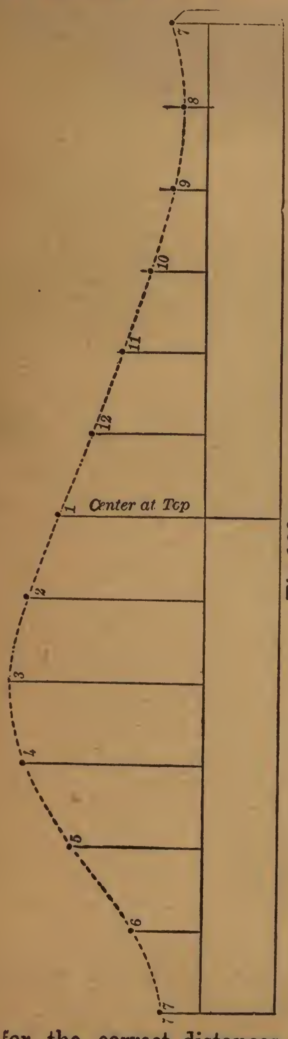


Fig. 103

The drawings are in every respect similar, and are to be drawn, with few exceptions, according to the general directions as given for the problem, Fig. 98. In this case I have drawn the entire plan of the collar. The drawing also shows the entire outline of the line of intersection of the collar with the hood, both in the plan and in the elevation. In developing the opening for the collar in the envelope the line 1 to 7 must be used for the center line of the collar, and for the measurements instead of the center line of the envelope, as in the other problems. This change is brought about by reason of the changed position of the collar on the hood, for when the cylindrical shape of the collar is moved around on the ever-changing outline of the cone in a horizontal or parallel direction with its base, the cylindrical shape of the collar not changing in the least, only its position from right to left, it follows that the vertical line from the top to the bottom of the collar assumes a different point of contact on the surface of the cone, whenever such shifting of position occurs. Just how much this is in this instance, is shown by the point 1 on curve 1, and point 7 on curve 7 of the plan. This distance has been transposed between the lines 1 to 7 and the center line of the envelope of the hood, and is also shown by the distance between the line A to X on the curve 7 to point 7 of the plan. All measures for the data must be taken to the right or left from the line 1 to 7 of the plan for the correct distances, for the distances on the curves of the envelope of the hood, use the line 1 to 7 for the center line. The data for development of the pattern of the collar, Fig. 103, is all so plainly shown in

the drawings that no furtner description of this part is necessary. The chief directions are similar in many respects to those given for the development of the collar, Fig. 99.

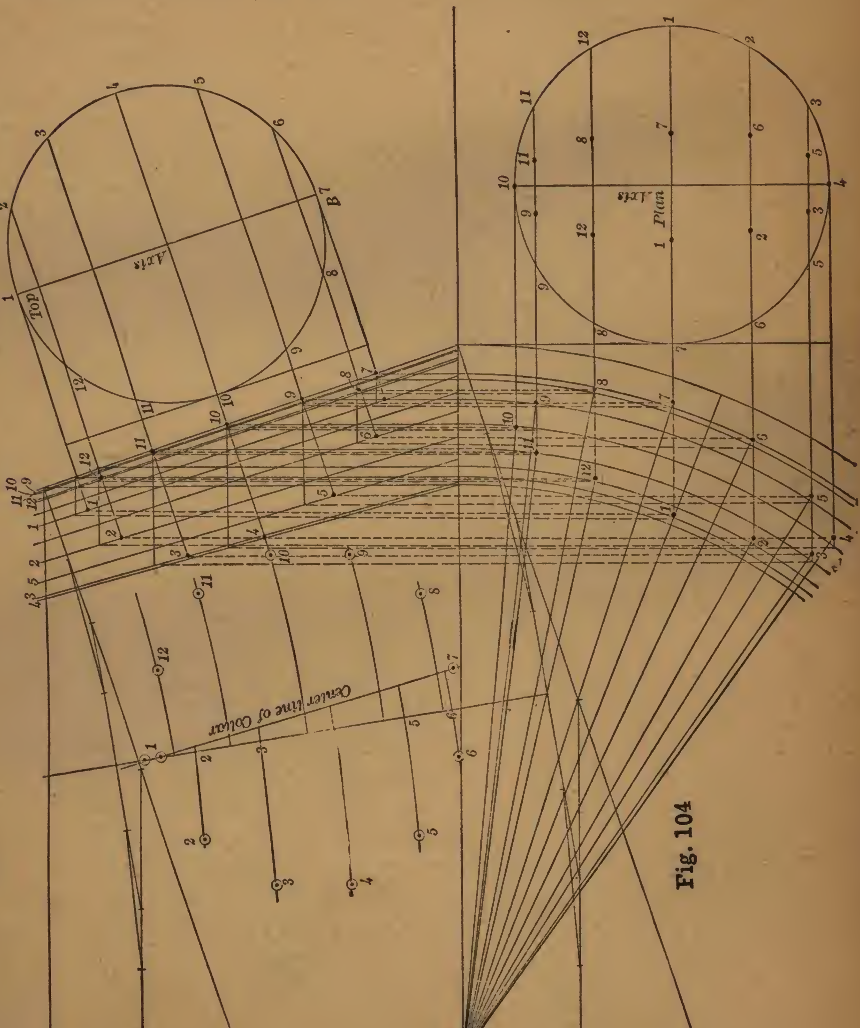


Fig. 104

The problem presented by Fig. 104 shows the collar at right-angles to the face of the hood, and as in Fig. 102, is a right or left-hand outlet. The general manner of finding these patterns is the same as used in the pre-

ceding Figs. 100 and 102. If the student thoroughly studies and masters them, this problem, being a combination of both the other two, it becomes a comparatively easy matter to find this pattern. There is some little difference in the disposition of the curves of the envelope which is brought about because in this case the inclination on the side of the collar farthest away from the center of the cone is longer, and as a consequence brings the lines a little farther down than those of the opposite side of the collars are. All these particulars are so distinctly shown by the drawings that they become at once apparent to the student who has studied and fully comprehends the problems given before, by Fig. 98 and those following it. Fig. 105 shows the fully developed collar as the elevation and the plan of Fig. 104 calls for, and is developed by the same general methods, as have been fully described in the foregoing problems, which have only to be applied for this case to attain the desired result.

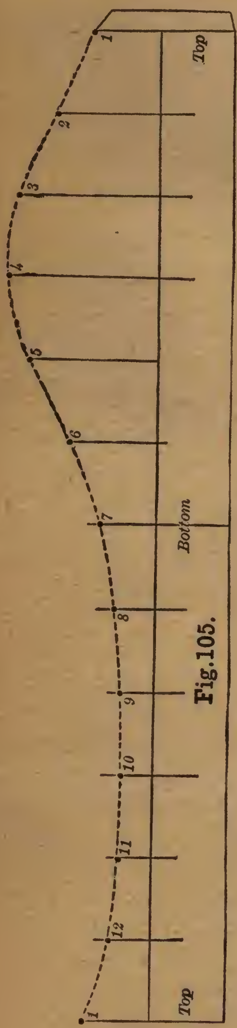


Fig. 105.

XVI.

FURNACE CASINGS.

In this chapter I will give some general rules and data useful to the student in making and arranging casings, air-inlets, water or vapor pans, and directions to arrange fronts for furnaces, portable or brick, and for setting them. I will show how this purpose may be accomplished in an easy and cheap manner. One great draw-back to many dealers who do not manufacture their furnaces is the wasteful way in which they are mounted and cased by reason of the style in which some furnaces are made. What is meant by this statement is that some makers of furnaces, when originally designing them, apparently gave no thought or consideration to the important and material-saving part, by having the casing rings properly placed and so distributed that the iron from which the casings have to be made would cut to the best advantage. In making up casings

for furnaces, it is always preferable to make them so that the iron will work in for the circumference of the casings the long way of the sheets, thus saving time and labor by reason of having less seams, which would not be the case if the sheets had to be cut crosswise. By using the sheets lengthwise, a far better looking, easier fitting and smoother piece of work is the result than otherwise.

If the casing ring is made so that it is situated at a distance so that any of the regular sizes of iron will be just right; that is, with only a small strip to be trimmed from it so that the sheet will be perfectly true and even, all would be right, but this is not the case in a good many furnaces. Sometimes they are either too high or too low. Instead of making the ring just high enough that either 24″, 26″ or 28″ wide iron will be right, it is often found that the ring when placed and fastened to the castings is just a half or three-quarters of an inch higher than any of the sizes of sheets mentioned will do for. This necessitates the workman either making the casings of short pieces cut across the sheets, or else using for the long way a size of sheet two inches wider than the size would be if the manufacturer had made the height of the casing ring as common sense would have shown it should be, if any of this very desirable commodity had been used in the original conception and make-up of the design of the furnace and the location of the casing ring. By reason of the rings not being properly placed, a strip one and three-quarters of an inch wide for the entire length of the sheet is wasted from each sheet used. It is not very encouraging or profitable for dealers to handle furnaces that are rigged up by such a wasteful method. The ideal furnace in this respect is one that has all its casing rings so arranged that to case the same, the iron will cut just right and without any waste. The correct way for the workman to get out a furnace casing is to trim the sheets perfectly square at the top, bottom and at both ends; give the up and down seams $\frac{3}{4}''$ lap and rivet them, the rivets spaced from 1″ to $1\frac{1}{4}''$ apart. Use 10 oz. rivets for this purpose and have every seam lay up well. Head the rivets neatly, and a first-class job is the result, far better than if the seams were double-locked and grooved. If the latter way is choosen to do this part, I would recommend to at least have the clumsy, bulging double seam put inside the casing, leaving nothing but the single crease outside to show where the seam is situated. One of the chief objections to grooving the seams together is that in beading the casings by reason of the four thicknesses of iron at that point where these seams are, no smooth and even bead can be swaged over them, but this can very easily be done over the riveted joint by any machine, and also without the risk of ruining or straining every part of it. I would recommend to bead every casing, as it

adds much to the appearance of a furnace and also makes the casing stronger and stiffer in every way desirable. One feature that every furnace casing should have, is that it fits snug and tight to the various rings throughout. To accomplish this is often rather difficult for the furnace man to do, as some castings furnished to him are made so rough and uneven, and the entire structure of all the castings so poorly lined and fitted that it is next to impossible to make a casing come right on such castings. My advice is to dealers, do not handle such goods, but buy from manufacturers who make well-fitting castings, and who care enough for their reputation to see to it that goods that are sent out to dealers are perfect in this particular. I have seen cases where it became necessary to resort to considerable stretching and bumping with a raising hammer to

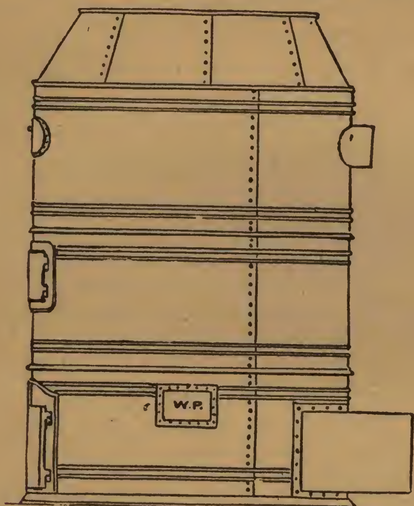


Fig. 106.

make the back part of casing on furnace fit to clean out castings, making it appear as if the furnace casing, at that particular point, had bulged out, or had a very bad swelling, this being augmented by the botchy system of not trimming the sheets level for the casings in the first place when they were made in the shop. The foregoing is sufficient to show the importance of having good work done by the furnace workman on the casing and of having suitable and smooth casting on which to properly fit his work.

Furnace casings are usually made in sections, in most casings there being three of these sections. The lower or bottom casing generally has the ash-pit door opening and sometimes the opening for the water pan cut out from its side. The middle part generally embraces the feed door section, while the top section is the one through which the smoke pipe passes,

and in some furnaces the clean-out doors are fastened. This style requires three casing rings, as is shown by Fig. 106. Other styles have only two wide sections as in Fig. 107. Some furnaces have one casing ring at the

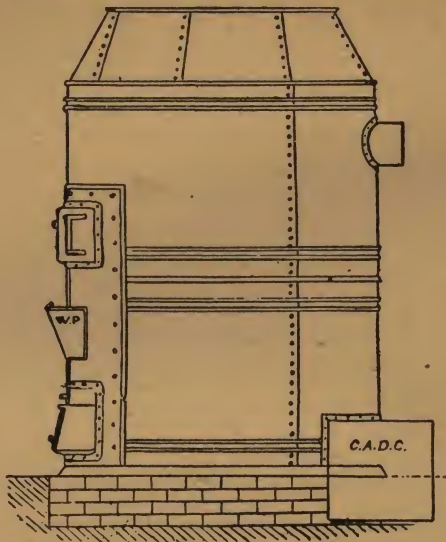


Fig. 107.

top, fastened in front to the cast-iron front while the back part is held by the casing as Fig. 108 shows.

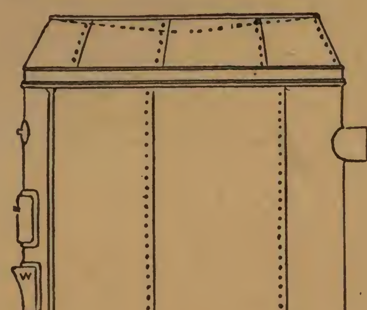


Fig. 108.

Every portable furnace should have an inside lining. This should be of bright tin and of an equal height to the casing outside, and should

also be if possible one inch away from the outside casing, so as to provide a cushion or partition of air between it and the inside lining, this preventing any undue radiation of heat through it. The manner in which these inside casings are fastened to their proper places is shown by Figs. 109, 110 and 111. Some casing rings, as in Fig. 109,

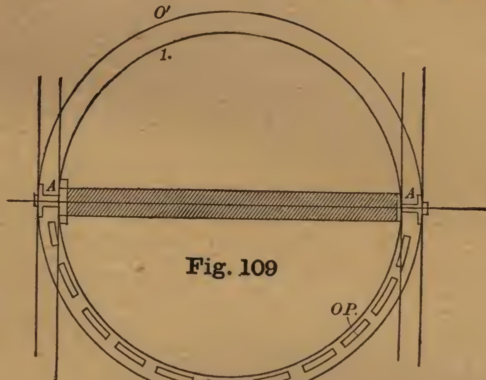


Fig. 109

are provided with an inside flange to keep the lining in its proper position. This style I regard as one of the best. Where no provision is made for a lining, as in the Figs. 110 and 111, the following methods are

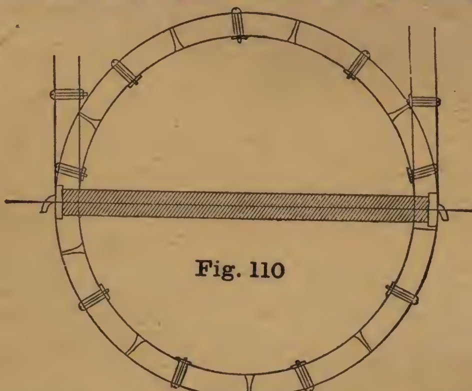


Fig. 110

used to some extent. The sheets are first crimped as shown by the part of Fig. 111 and are then riveted to the casing, each sheet with from four to six rivets. Fig. 112 shows a special stake made for the purpose of holding on the nivets from inside, the rivets being hammered down and headed outside of the outer casing. A of this figure shows a rivet driven and headed; B shows a rivet drawn through the outer and inner casing, and ready to drive. The stake C is shown one-quarter size, but the face D is

about actual size. A suitable handle is provided for the stake whereby to hold it up against the rivet. The holder holds the lining sheet in the place where it is to be fastened, and also the stake until the sheets are all done as desired. F of this figure is the corrugated or crimped lining tin; H is

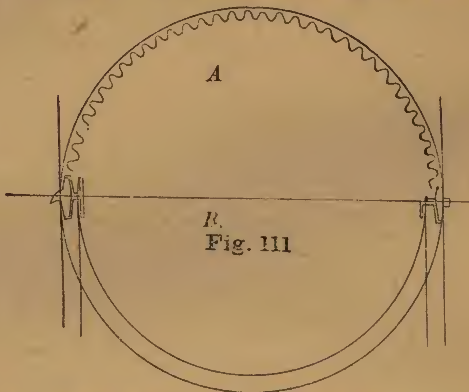


Fig. 111

the outside casing. When the casing ring, as a good many are made, has no special lugs or an inside annular ring for linings as in Fig. 113, a sectional view of a very good substitute is shown this can be made as the figure

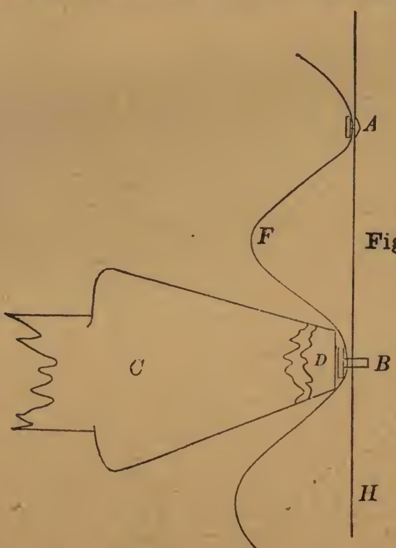


Fig. 112

shows out of any suitable piece of iron. These lugs must, as a matter of course, be made strong enough to hold the linings in place.

By this method the lining tin can be made solid or in one continuous

piece all the way around as the outside casing is, providing the same is so, or the conditions admit of it being made as indicated. In case the outside casing does not go all the way around the ends of the lining must be riveted to the same in the proper place so that the same retains its correct distance from the casings at all times. B of Fig. 111 shows both casing and lining done this way. The Fig. 113 shows all the foregoing in detail

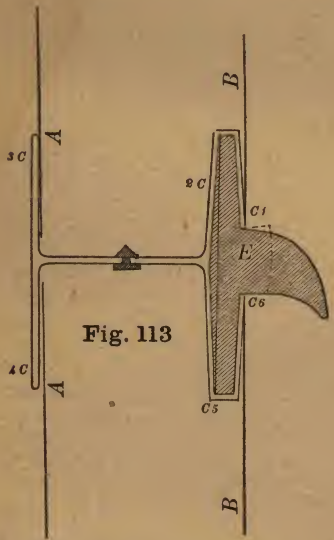


Fig. 113

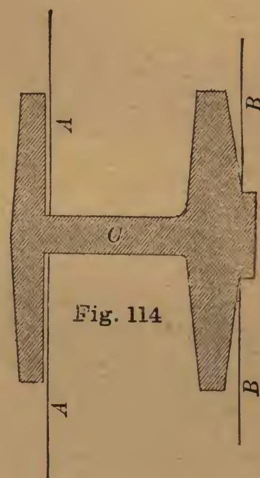


Fig. 114

connected with this mode of fastening. A A is the lining in position held so by the lug, made as described; the entire shape of the same is shown by C^1 to C^6. E is the casing ring and B B is the outside casing. The best ring made for the purpose of holding both the outside casings and also at the same time the lining into its proper place, is shown by a section as the Fig. 114 shows. This style ring, as a matter of course, is only furnished with the more expensive styles of furnaces to the trade, these rings being the most expensive kind in use, and I may add one of the best styles known. A A are the linings and B B the casings. C is the section of the ring as described. In this part of the same, as at C, there are at short intervals parts left out to let the air circulate between the lining and the outside casing; this is shown in the Fig. 109 to some extent. One advantage and saving of labor by using this style ring is that the entire inside lining can be made in one piece, the same as the outside casing is made, and the same can be slipped down into its final position in the furnace, that is, after the proper openings have been cut out of the same, so that it will allow the doors, smoke pipe, or whatever projection passes

through it according to whatever section the lining belongs to. The Fig. 115 gives a detail drawing of another good method of fastening a lining to the casings. The figure shows the lining fitted into the furnace complete. This is done in the following manner: The lining sheets are first slightly broken or formed, then an edge one inch wide is turned at each end at right-angles, as shown in the Fig. 115. Place the sheet in position as wanted

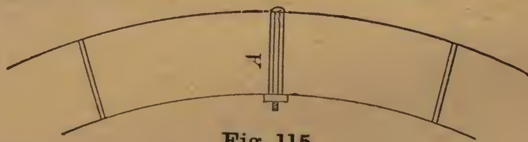


Fig. 115

and fasten the same to the outside casing, each sheet with two 3-16″ by $1\frac{1}{4}$″ round-headed bolts. To prevent the lining from bending or laying up against the casing, the small ferrule as shown at A is put between the lining and the casing, the bolt passes through this ferrule, then the nut is put on the bolt and screwed or turned tight, thus holding the lining tin rigid and permanently in place. Two bolts or fastenings as described are needed for each sheet of tin used. The foregoing method is a very easy and quick way of accomplishing the desired result, being in my opinion as good and cheap a way as could be used under the circumstances for this purpose. The main object and aim should be, when putting a lining into a furnace casing, to try and have the same to cover every part of the exposed outside casing as it is possible, and also to have it as smooth as possible so as to allow the heated air to pass through and up the enclosed inside space between the lining and the heated plates of the furnace with as little friction as possible. Also see to it that the lining stands well away from the outside casing, as demanded by the directions given. The cold air which finds its way in from below from the cold air inlet, in between the lining and the outer casing, gradually rises upward as it becomes heated, and finally flows in and mixes with the heated body or volume which passes over the plates of the furnace. This amount of air which thus passes upward between the lining and casing by reason that it is not heated as much as the inner volume, as before stated, prevents the air from chilling and also from radiating any of its absorbed heat out through the casing, but directs the same to the outlets in the bonnet or hood of the furnace. It is very evident that to fulfill all the required conditions that the brighter the surface presented by the material which is used for this purpose the better it will serve the end aimed at. Bright tin-plates being the most suitable material and also the cheapest for the purpose, nothing else should be used. Do not use roofing plates or, worse still, common black sheet iron, but if the cheapest stock must be used,

bright coke-plates are the best as a substitute for charcoal-plates, which I regard as the best for this purpose.

Furnace casings for portable furnaces are generally made of galvanized iron, usually of either 24 or 26 gauge iron. For room heaters Russia iron is usually used. As these latter heaters are nothing more or less than furnaces, but cased with Russia iron casings, and differing only from furnaces in so far that instead of being used to heat rooms and apartments that are in most cases located above the room wherein the furnace is set, the room heaters are mostly used to heat the room or space wherein they are located. This being the case, I included this latter in the general description as given.

In addition to the styles of casings already described, to make the list as complete as it can be as will be of interest to the student, I will also describe several kinds of casings not in the usual line as made by the average furnace firms. There are at the present some firms making casings that are somewhat similar to the casing as shown by the Fig. 108, but differing from this style, that instead of the casing being made solid, or riveted together in one entire casing only, they make them so that each sheet or section can be detached from the main body of the casing. The claim is that by being able to do this they can get at any part of the furnace any time to examine the same, to see if any repairs, etc., are needed; also, that they are more handy to be gotten at, etc., than furnaces that are not built that way. Just how they would manage to replace a broken or burnt-out fire-pot without disarranging the entire structure, or even how it could be managed with all the elaborate and complicated fittings that are peculiar to this style of casing, to replace a part, as mentioned, with less cost or trouble than what the same operation could be done with a more simply arranged apparatus, is not so easily to be seen. Then another point: considering the first cost of this style, it is considerable higher than the styles usually mounted and set up by furnace men generally.

Another style of casing brought out some time ago is also made in sections somewhat resembling the Fig. 108, but made of a composition of cement, plaster of paris, etc. This casing is made about from $1\frac{1}{2}''$ to $2\frac{1}{2}''$ thick in exactly the same shape and form as the ordinary casing for portable furnaces are, but presents more of the appearance of a stationary or brick-set furnace when set up than it does like a portable one. This style casing possesses some commendable points of excellence, although rather an expensive arrangement for the purpose.

The practice in some of the smaller shops where but few furnaces are got out or mounted, and also in some of the more pretentious and extensive establishments, particularly in such where they handle perhaps a half-dozen different kinds and makes of furnaces, is as follows: I will assume that a certain size of some particular manufacturer's or leading firm's

furnace is to be mounted and fitted with a set of casings, while the very next job that would have to be done would be the mounting and fitting of casings for an entirely different kind, style and make of furnace, these two instances showing the wide range and diversity of furnaces that the workmen are called on to mount in this class of shops. The first step taken is to set up the furnace castings complete or as near as is necessary to measure and fit up the casings for the furnace under construction. It is understood that the proper place to set up a set of castings as mentioned should be a perfectly level floor. After the foregoing has been done, take the first casing ring as X of Fig. 107 shows and bolt the same to the iron front as at X′ of the same figure, that is, if the furnace mountings are of this class, with either two sections of casings or three as the case may be, and with an iron front. The shape of the casing of course may be either circular or oval in shape as the case may be. If no cast-iron front is used with the furnace as the style Fig. 106 shows, the height of the casing may be deducted from the height that it must be to clear the frame of ash-pit, door, etc., and also so as to come within a reasonable height from the frame of the feed door. For the second section of this style furnace casing the height of the same must conform to any requirements that this section of the furnace castings demands of it; the same also applies to the third or top section of this style of casing, being for this latter section the clean-out and smokepipe outlets and fittings. All the above deductions may be modified in so far, that is, so as not to conflict with absolute imperatively fixed conditions, as the positions of the height of the ash-pit door frame, the feed door frame and the smokepipe outlet, clean outs, etc., demand for the same to be, so that they conform to the most suitable and waste avoiding method to cut the iron for the casings as demanded for this style of furnace. This last consideration mentioned should never be lost sight of by the workman. Whenever it is in his opinion desirable to change the height of a casing so as to save stock and avoid waste, that is, if he possibly can do so, one way or the other, without too much trouble and also with some reasonable regards as to the proportions of the different sections that they are desirable to have to each other, as the casing will present when finally it is set up in position on the furnace.

Of course the latitude allowed in the foregoing to the workman, as to the determination of the various heights, etc., that he can make in the sections, does not enter at all into the consideration of the height of the style of casings as shown in the Fig. 107, where the height of each section is already fixed by the position into which the casing ring is bolted or fastened, so that it cannot be altered, if the same should be fitted so that to make the casings as demanded cuts the iron to waste. All that can be done on this particular point is to perhaps continue to handle a furnace of

this class and bear the loss, or have some other manufacturer's furnaces to mount which are more sensibly designed so as to avoid this particularly wasteful manner of casing for the same. The workman, bearing in mind whichever points as given in the foregoing may apply to any particular job he has on hand of this class, may now proceed to take his measures and data for the casing. In the first place take a long metal strip and get the exact measure of the circumference of each and every casing ring that is to be used on the furnace under consideration. Be sure and measure both flanges of each ring, note the same, and in most instances it will be found that they vary from being the same in size as the other rings in most cases are, in some cases they run a l the way from being $\frac{3}{8}''$ smaller up to $\frac{3}{8}''$ larger in circumference than any one particular ring, which I will assume it is intended to use as a standard measure. This annoying and bother-

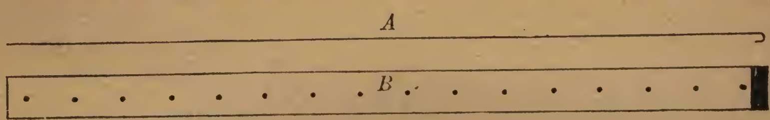


Fig. 116

some variation from what sizes should be, I have found in most all makes of furnaces. After the measures are taken for the circumference for each ring or place where the casings are to fit on with their extreme top or bottom ends, whether for round, oval or square casings, determine the height that it is necessary to have each section. Then lay out and cut the required pieces of iron for the same.

When this is done mark off the front and back center line on the iron for each section, and allow for laps at the same time. When the sheets are to be riveted together use the largest pieces for the front as shown by the Figures 106 and 107, and have the laps so arranged from the front that they lay over the rear pieces, this on both sides of the furnace. For laying out the rivet holes, a very convenient gauge is shown by the Fig. 116. This gauge is made as wide as it is intended the lap should be, and the holes are made in the same exactly in the middle, spaced as far apart as it is desirable the rivet holes should be in the casings under consideration, either $1\frac{1}{4}''$ or $1\frac{1}{2}''$ apart. A bend or hook is turned at one end so as to enable the workman to hook this end firmly to the edge farthest away from him; drawing the strip firmly toward himself he can mark off the holes as desired, on any desired number of pieces all being alike by reason of the hook or gauge at one end of the marker being employed alike on all pieces used. This working strip may be made 30″ long by $\frac{3}{4}''$ wide as shown by A and B of Fig. 116. Next take all the measurements for each particular opening, etc., that may be required in any particular section of a casing. Note any

peculiarity, if any, about the lining up of the furnace and allow for this point if necessary.

Mark all the openings and pieces that are to be cut out of the casings as found on the same, each in its proper place, and then swadge the beads as wanted before cutting out the pieces as found by the measurements described. The cutting out of these is the last operation which completes the casings, ready to be put on the furnace now in position on the floor and from which all the measurements have been taken. One point that must also be borne in mind is that a suitable allowance must be made for the openings in the casings if the same are cut out in the shop and measured; that is, the additional height that the cement, kaolin or putty adds to the castings when the same are finally put up at a job, must also be allowed for while measuring up the data for the fittings. The foregoing give one one of the best systems how to do correct and good work in this branch, and is one that is to be recommended. In some large shops where mostly only one line of furnaces are handled, that is, of one manufacturer's exclusive make only, a system as outlined as the preceding to obtain the correct data

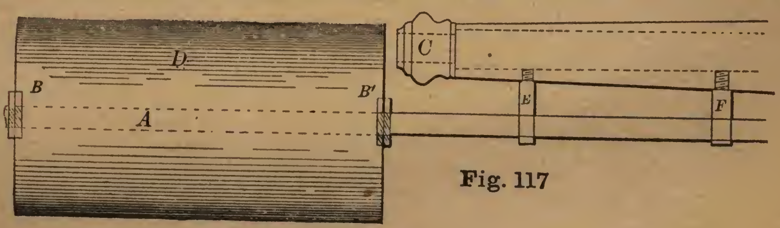


Fig. 117

for the casings of furnaces, is also followed, the only difference in these latter shops, that is, if the same are conducted on the most approved plan of economy of time, labor-saving appliances, etc., the entire patterns of every section of any furnace that is made in these shops is gotten out by the methods as shown and patterns are kept on hand for future use. This of course is a matter of some expense and it would hardly be policy for the smaller shops to do so, simply by reason of their so often changing from one line of furnaces, to other makes and patterns of some other manufacturer's goods in the same line. But I would advise for every workman to keep a complete record of every item in connection with any furnace that he measures. This may often save considerable trouble and work at times, and as a consequence, some expense, if such a record is kept. I have seen instances where men have been promoted to positions of foreman and even more responsible and better paid situations by simply jotting down and keeping a memorandum of all data, measurements and peculiarities of the different sizes, etc., of furnaces that they worked on while working as

journeymen at the bench. The instances alluded to happened in shops of several of the largest firms in the furnace trade. These men, as is to be seen by the foregoing, took an interest in what they were doing, and that, I may add, in the right direction. Knowledge of this kind pays.

One of the handiest—and very desirable—helps to be made use of in swaging the beads on the casings is shown by the Fig. 117. This shows as revolving cylindrical drum with two heads, fastened one at each end, a rod being passed through and slipped into suitable fastenings underneath the lower part of a large size beading-machine, allowing the drum to revolve in the direction in which the machine is swaging the beads in the casing, and at the same time turning the same and also holding the casing so that the same does not kink or buckle while the beading operation is being done. The figure gives all necessary proportions to construct such an appliance. Of course, such arrangements must be made so that the general dimensions of the drum suits the general size of the machine on to which it is intended to be

Fig. 118

used. To give more directions than what has been given in this instance for the general or precise way in which a drum of this kind should be made would be useless. Considering the many different styles and kinds of beading-machines in use the student will readily see that this would require too much space and also necessitate wading through too much minute description of all the different kinds of machines in use, and perhaps then by oversight the very kind that he is most interested in may have been omitted. For this reason the Figs. 117 and 118 are simply introduced to give a fairly good idea what is meant by this description. In some cases it may be necessary to provide entirely different fastenings for the rod to run in on the bottom of the lower arm of the machine that may be at hand on which it would be intended to put a drum attachment to, as described in the foregoing.

The following gives the explanation of all the parts as shown: E and F are the fastenings to the lower arm, A is the rod which passes through these and also through the entire length of the drum, fastened solid to the same by the lock-nuts at B and B′. D is the drum proper, and C is one of the rolls of the machine itself. The Fig. 118 gives an end view of all the

foregoing parts; this view has been added so that the side view can be more readily understood and the relative positions of each part seen at a glance.

In fitting the casings on to a furnace care should be taken that the inside linings are not cut out too much, but just sufficiently so that the parts intended to come through the same can do so and the lining does not interfere with the setting up of the furnace; that is, as all furnace men are aware, the linings must be cut out a little larger than what the parts would seem to demand in order so that enough play is allowed for the linings to be easily gotten into their final place and position when the furnace is set. One point to be particular in is to have the openings for the smoke outlet and clean outs fit tight on to the castings. The best way to do this is to cut the opening 3-16″ or a ¼″ smaller than what the castings demand. Then turn an edge with a special tool, or a ball-faced hammer, outward from the casing, making the opening large enough so that the part it is intended the opening is to fit over can pass through the same nicely.

This same rule applies to any other part of the casings where outlets are to be fitted. It is the practice with some firms not to bead furnace casings that are intended to be shipped out into the country. This is done so that the same can be more conveniently rolled and packed together in smaller parcels. This serves this end well enough, but the casings do not look as well when finally put up as they would if the same had been beaded and shipped with a little more trouble. This small item alone has often induced a purchaser to buy a furnace of firms who gave this point its due attention, in preference over those that paid no regard to this point in the case, and thereby lost a customer to whom they perhaps could have sold, other conditions being equal, if their furnaces had been gotten up in an attractive style, as those of their competitors were, namely, that the casings were beaded.

In getting out casings for the type of heaters commonly designated as room heaters, one of the first considerations should be to ascertain for what purpose the heater is to be used, whether the space which it is intended to heat with the same is on the same floor, or, in other words, if the heater is to heat the room only wherein the same is put up, or if in connection with heating this room it is also intended to heat additional space or rooms located above the one in which the heater itself is located and put up.

As it is the custom with most firms to put no linings into the room heaters which are intended to heat one room only, and that wherein the room heater is located, it may be of value to the student to know how these are arranged and also how to arrange and put the heater in shape, so that it answers to heat both the lower and also the upper room or space. The methods are as follows: The casings are generally made of Russia iron

(American Russia preferred) of medium gauge, the up and down seams either riveted or the seams are locked and grooved with the groove on the inside of the casing. On heaters of this kind no hood is used, but mostly instead an open cast-iron screen is placed on the top of the same of some ornamental pattern. Some furnace firms do not put any top on their heaters at all, but simply put a rim at the top of the casing, which is in some cases of a fancy pattern, ornamented with a brass band, as are also the rings around the casings tastefully beaded and polished. I may add that the last described style has a showy and very fine appearance when set up and all the parts are well polished. These heaters should always be made with the sheet running lengthwise with the circumferential way of the sections; this way they run with the grain of the sheets and have the best appearance, and the iron works to the best advantage in every respect, presenting less liability to crack or break in working, and particularly does this apply to the genuine Russia iron with which the American market is supplied at the present day.

Do not use the sheets crosswise if it possibly can be avoided, as this detracts greatly from the general finished appearance of a set of casings, also makes more seams, more liability to cause the work to be uneven, more rivets and more waste of time, as compared with the shorter and better way of using the sheets whole. It may hardly be necessary to add that these casings are generally nicely and tastefully beaded. For those styles which have the air inlets above the floor or foundation upon which the heater is set, two or three cast-iron screens are placed or riveted to the lower edge of the casings over openings cut out of them to fit the same. Some room heaters also have foot rests or foot warming appliances affixed to the casings. Whenever a heater of this class has an outside duct to supply it with cold air, the screens as described are as a matter of course dispensed with. A full description of how these ducts are made and arranged will be given further on

In the foregoing the common style of room heaters has been described The following method gives the best results where it is required of a room heater to heat rooms or space both overhead of the heater and also the room wherein the heater itself is set. Casings for heaters of this class should never be put up without linings, nor should there be any cold air inlet direct from the room wherein the heater is set into the heater; the fresh air should be taken through a duct from the outside. Heaters of this class are mostly put up in the basements of churches, halls etc., where the room wherein the heater is set is used for a school-room, meeting or class room etc., one large pipe conveying the warm air to the main audience or lecture-room above. In cases of this kind it will be found of benefit to have those parts

of the hood which have no outlets, etc., to interfere with a lining, also lined. So that when all the heat is required for the upper room, and all the outlets are shut off for the lower rooms, all the heated air will flow up through the pipe, and this without any heat being dissipated or lost through that portion of the hood which, if the same were not lined, would be very apt to cause such a loss of heat to a greater or less extent, the casing and hood being made of Russia iron, which, in itself a material which very readily would radiate or lose heat, is prevented from doing so by the intervening tin lining, thus saving this amount of heat for the room above, to which it is intended it should go. The arrangement of the outlets for a case of this kind is as follows: The large pipe leading to the upper floor may be put in the center of the hood, while the outlets for the lower room may either be located by the sides of the large pipe on the hood, using two circular registers to regulate the flow or amount of the out flowing heated air, or else the same purpose may be accomplished by using one large register, and this located in the upright pipe at or near the hood, the upright pipe being provided with a tight-fitting damper above the same. The damper in the upright pipe enables a person to regulate the flow of air so

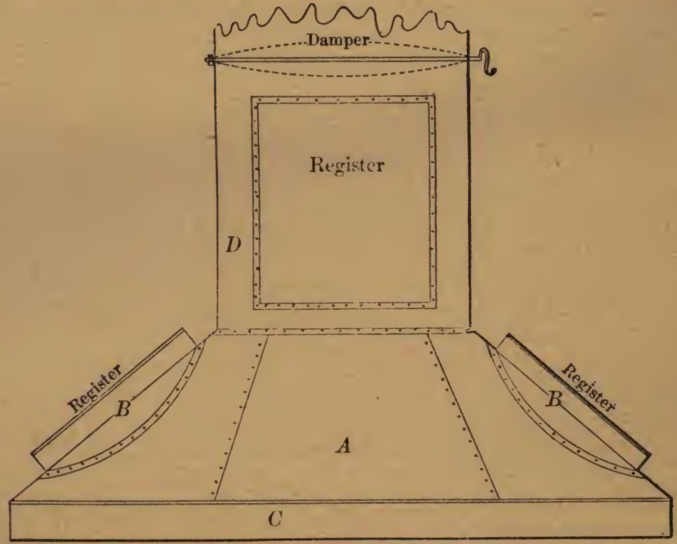


Fig. 119

that the same can be entirely cut off from going to the upper room and all flow through the outlets into the lower room, or the damper may be opened and the outlets closed so that it will flow up only, and none go to the lower room; and again the outlets and also the damper in the upright pipe may

all be opened, which will allow the air to flow to the two rooms at one and the same time, each room or space being supplied according to the capacity of the outlets to the same, whatever that may be in the case. The Fig. 119 shows the entire outlets as described in the foregoing. A is the hood proper B B are the circular registers. C is the band of the hood. D is the upright pipe with the damper shown at the upper end, also showing the face of the register, which may be put in that position as shown in the figure. For the cheaper grades of furnaces some manufacturers do not furnish any water or vapor pans for the same. This being the case, it depends on the furnace-man to supply this deficiency as best as he can. As no regular size can be determined on with certainty owing to the variable degrees of heat of the air surrounding the vapor pan most of the time, I will omit to give any positive or arbitrary rules on this subject at this time,

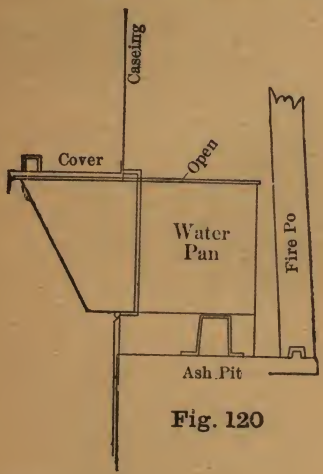


Fig. 120

Fig. 121

but will reserve it for a future special treatment in all its phases. As wat pans for furnaces are rarely made any larger than what the capacity of an ordinary water-bucket is, and in most cases even less, in fact, even if it would be desirable to have the water-pan larger, this could not be done, owing to the peculiar construction of most furnaces, as no suitable or larger place is provided for a pan than somewhere near the size as indicated for this purpose. The Figs. 120 and 121 show two styles of easily-made pans for this purpose. Fig. 120 is a pan made of galvanized iron having as few seams in the same as possible, rivet, stop cleats to the sides and bottom, so that the same cannot be pushed into the body of the casing any further than is desirable that it should go. The figure shows a side view of a pan made for a furnace or room heater placed in position so that the pan rests

on a brace provided for the same as shown resting on the top of the ash-pit. The pan is wired all around the upper edge, and open only on the inside of the casing. A moderately tight fitting cover is provided for the part which projects out from the casing. The opening which is cut out of the casing is to have a wire laid in all around its edge so as to make the same firm and strong enough to bear the strain imposed against this part of the casing so that the same does not bend or buckle when the pan is filled with water, even if it were not provided with a rest as shown, which would be the case if the pan were located on the side of the furnace casing instead of at the front part, as the Fig. 120 shows it in this case.

The opening when completely wired all around must be made so that the pan fits into the same snugly, but not too tight; in fact, must be a good fit, and the job must be well made throughout.

The Fig. 121 shows a cylindrical shaped water pan, and also a similar shaped sleeve or support to hold the same into position. The sleeve, into which the water pan is to fit nicely, is to be of equal length to the pan and is fastened to the casing either by being double seamed to the same or firmly cleated as shown in the figure. The sleeve as shown in the drawing has an open top equal to the size of the open top of the water pan. The water pan as a matter of course has a head at each end fastened to the cylindrical part. These pans are mostly made of galvanized iron well soldered at the joints with a handle provided at the front end to draw the pan out so that it can be conveniently filled, etc. In case this kind of a pan is to be used for a Russia iron casing an extra Russia iron cap or head is put on over the galvanized head of the pan, the handle of course being put on the cap as last put on over the first head. There are several other styles of water or vapor pans made to answer the purpose as set forth, but I regard the two styles given as being as good if not better than any other kind that ever came to my notice, and for that reason have given but these two styles, believing that they will meet almost any requirement that could be made of a cheap and good water pan that is located as low down as these are in a casing.

In the cheaper grades of furnaces it is also customary to provide rests or lugs to lay the shields or trench-plates on, which are used for them over where the cold-air duct connections are fastened to the casings. These plates are necessary in some furnaces which are set on a solid floor or foundation, as the Fig. 106 shows an example of. The cold air being taken in through the casing, either from the back or from either side, as the case may be, does not distribute itself by this method of entering the furnace as readily as it would if the same were taken in from underneath the furnace

by an underground air-duct and a specially prepared pit for the furnace to be located on or over. This being the case, and the air entering in one compact body at one particular point of the casing only, it has a tendency to rise at once; but in order to diffuse and to distribute the amount of air coming into the casing from the cold-air duct connection as much and as evenly as possible, the trench-plates, or shields, as some furnace men term them, are placed directly over the cold air inlet of the furnace casings, and, in order to be able to so place the plates, the before-mentioned lugs are fastened to the casing as described. It is almost needless to state that this manner of connecting the cold-air duct connections is one of the cheapest modes known to accomplish this result, and although not the best manner in which it could be done is nevertheless used by many firms on cheap work. The connection for the cold-air duct is made of galvanized iron and is usually made to extend away from the furnace casing to the extent of the width of a sheet of iron from which the cold air-connection is made and from which width the curve that is to fit on to the casing has also been cut out, from both the top and bottom sides of the connecting piece. This connecting piece is in some cases riveted or in others bolted on the casing, from which a correspondingly large opening has been cut, to allow for the passage of cold air to the furnace. Braces are also put into these connections to make them stiff and keep them in shape.

The Fig. 107 shows a cold-air duct connection which is let into the furnace only half of its height, while the other half is taken in underneath the furnace, which is set on a shallow pit corresponding in depth to half the height that the cold-air connection has, which is shown connected to the same in the Fig. 107. This style of a connection is a decided improvement over the style shown by the Fig. 106, and is often made use of where it is impracticable to dig a deep pit for the purpose, but still desired to make a better connection than is shown by the Fig. 106.

The inlet as shown by the Fig. 107 also requires that shields or trench plates be used over the same; these are put in as described for the other style.

It is the custom in some shops to make for certain sizes of furnaces a standard size of ready-made cold-air inlets, each particular size furnace having an arbitrary fixed size inlet for itself, and I may add it is often used, no matter whether the demands on the furnace call for a few or many heat outlets in the hood of the same furnace. Question one of these workmen why an inlet (that is nearly a third size too small to fulfill the required duty that will be demanded of it when the furnace is in operation) is not made the proper size as the case demands it to be, he will probably say that the foreman gave him the pattern and so he made it as the pattern

calls for. Then if one cares to follow the matter up and inquires from the foreman how he arrived at the result as embodied in the pattern after which the duct-connections are cut, and that without regard to how few or how many outlets there may be to the furnace, I doubt if the average foreman could give an anything like a satisfactory answer. To state the case plainly, it will be found, that the real knowledge on this subject that the average furnace-man possesses is not what it should be; in fact, a good many are lamentably deficient in most of these necessary branches which are of so much importance, and which they must necessarily be masters of to be what may be termed first-class men in furnace-work.

The lack of definite information on the cold-air supply for furnaces is only one of the branches in which it would be of benefit to all concerned if more scientific and accurate methods were used in proportioning the supply of air for furnaces, than the haphazard methods which are mostly used by furnace-men, and which are at their best but guess-work. A full exposition of this subject will be given in these articles in due course.

It may sometimes be desirable to change a casing of a furnace from a portable to a brick-setting. As for instance, if it is desired to add more heating or radiating surface to a furnace, in case of this being a portable-cased style, for which it is impracticable to use a portable casing after such a change has been made, the following gives an easy and cheap mode to effect such a change: The first point to be considered is whether the front is to be made with a flat or round back; this is determined by the shape that the front sections are made in. If the same are rounding, or somewhat in the style as the Fig. 106 shows, the back of the sheet-iron front must be made curved or rounding, in order so that the back of the same will fit and conform with the surface of the castings that protrude from the furnace proper, such as the ash-pit and feed-door sections. The furnace, as Fig. 107, shows would demand a straight back for a front of this kind.

This point settled, the next step would be to make a drawing for the style front as wanted. The Figs. 122 and 123 show two perspective views of these fronts. Fig. 124 gives full detail drawings of both styles as indicated in the foregoing. This figure shows a front elevation, A; B is the lanp and C is the side elevation when done. It will be noticed that no measurements as to the height or width of the front elevation have been given, these considerations depending wholly upon the circumstances and conditions into which the front which it may be intended to make is to fit into and has to comply with. The height of most fronts made by this method are that they are made a little higher than the front feed-door frames or the furnace itself is, as at the point S″ the distance to the point S of the lowest point of the

back of the front should be from 6″ to 8″ inches higher than the frame which fits around the feed-door section is. This of course is not arbitrary, but the workman may be guided by the fact that in the first place his aim should be to make the front look well—that is, high enough so as not to look

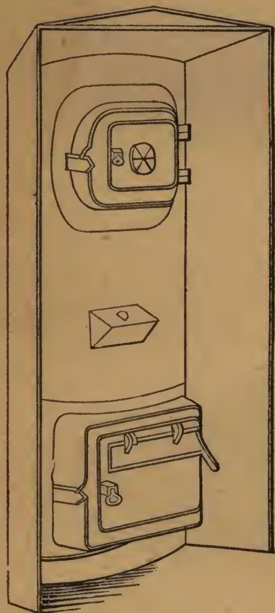


Fig. 122

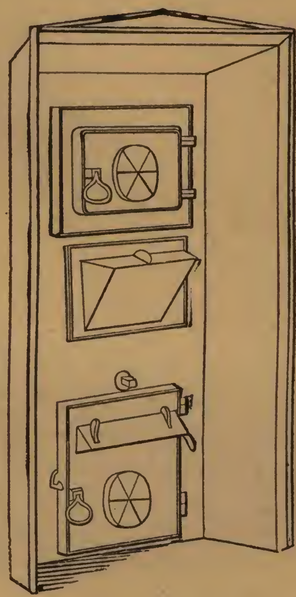


Fig. 123

squatty or too low down, bearing in mind at the same time that for this matter of looks or beauty, not to sacrifice too much of the utility or main purpose which the front is to serve; namely, to produce by this method a front which will answer every purpose it is intended it should for use, and that as cheap as it possibly can be, as is consistent with a first-class piece of work in this line.

As to the width or depth of the fronts, as the side elevation C shows these are mostly from 5″ to 9″ deep, and made as to the flare that it should have in most cases as suits the taste and ideas of the person designing the front. Lay off a $\frac{3}{4}$″ flange all around the front; three styles are shown for the top part or pediment over the front. Th s may either be made of sheet or cast-iron, as suits the fancy. If the front is made of sheet iron a $\frac{3}{4}$″ by $\frac{1}{8}$″ band is to be formed and fitted to the $\frac{3}{4}$″ flange, up one side to the top, there continued across the front, formed to whatever shape the front is made into, and then down on the other side

again. This band is to be nicely riveted to the flange, thereby strengthening and securing rigidity to the front. The bands are to project about 3″ down below the lower end of the front as shown. This is to have these projections bricked in at the bottom so that they cannot by any chance move away from their position; the fronts in fact, are firmly anchored there by these projections. The other anchors, shown by the plan as at D′ and E′ and correspondingly by E and D in the side elevation and also in the front view, are so placed to secure to brickwork firmly to the front. The plan B shows a straight back and also two shapes by the dotted lines, one made a little more rounding than the other. Dotted lines are shown in the front view correspondingly as demanded by the lesser curved back. These

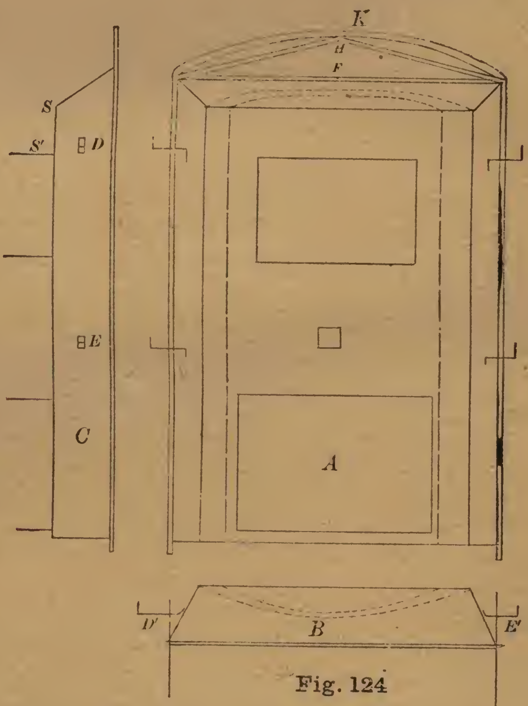


Fig. 124

fronts are generally made of 22 gauge black sheet iron, which is about the best thickness for the purpose, although I have seen them made of lighter material, I would not recommend lighter iron than 22 gauge for the purpose. These fronts may be painted with asphaltum, which makes a good finish. Practical examples of fronts as described will be shown in the course of these articles in due time, showing how they are fastened to fur-

naces, how they are set in the brickwork and how to measure the openings that are to be cut out of the front, as the case may be, for the various connections, etc., that the back of the front has to fit over or on to; also where the back is or has to be made flat or, *vice-versa*, it has to be made curved or round.

ELBOWS AND CONNECTIONS.

CHAPTER XVII.

The next branch of furnace pipe connections which I will discuss is the different styles and kinds of elbows, such as those made of tin, galvanized iron and also out of the heavier grades of black iron and steel. I will first consider the common style made out of tin. Fig. 125 gives a full line of standard furnace pipe elbows, as usually made throughout the entire country by furnace men for this class of work. The style A is the four-piece square elbow made at an angle of 90°. B is the three-piece angle made of three sections of a square elbow, the miter line being the same for this style as for a 90° elbow, but the angle having only three sections. C is the four-piece elbow made with a rise of 1″ to the foot, as the drawing shows. These elbows are usually called off elbows, by furnace men. As will be seen in Fig. 125 these elbows are also made out of three pieces, as D shows. It is customary in some shops to make 90° square elbows in three sections, but this is not so generally the practice as to entitle this last described elbow to be designated as one of the standard styles. The three styles of angles shown in this figure are two-piece angles. No. 1 is made of two parts of a five-piece elbow, or in other words, the angle that the mitre line for the parts of this angle is cut to, is the same as for a five-piece square elbow. No. 2 has the mitre line of a four-piece and No. 3 that of a three-piece square elbow. These three styles are standard in all shops and are usually made up in quantities as stock.

In elbow work, the first consideration is the kind of material out of which an elbow is to be made, next the general size as to its diameter. how many sections or parts the elbow is to be made of, then finally, what angle the entire angle or elbow is to have when finished, and how it is to be fastened together at its different joints, whether rivited, double-seamed, pinned solid or loose, so that it can be made reversible, if so desired. The foregoing is, in brief, the entire list of points that will have to be taken into account when an elbow pattern for any certain kind is to be gotten out in the course of ordinary work such as

occurs in all furnace shops. In the ordinary course, elbows that are made at 90°, no matter of how many pieces, certain fixed conditions are to be followed, such as the degree of the miter line or the height of pitch each

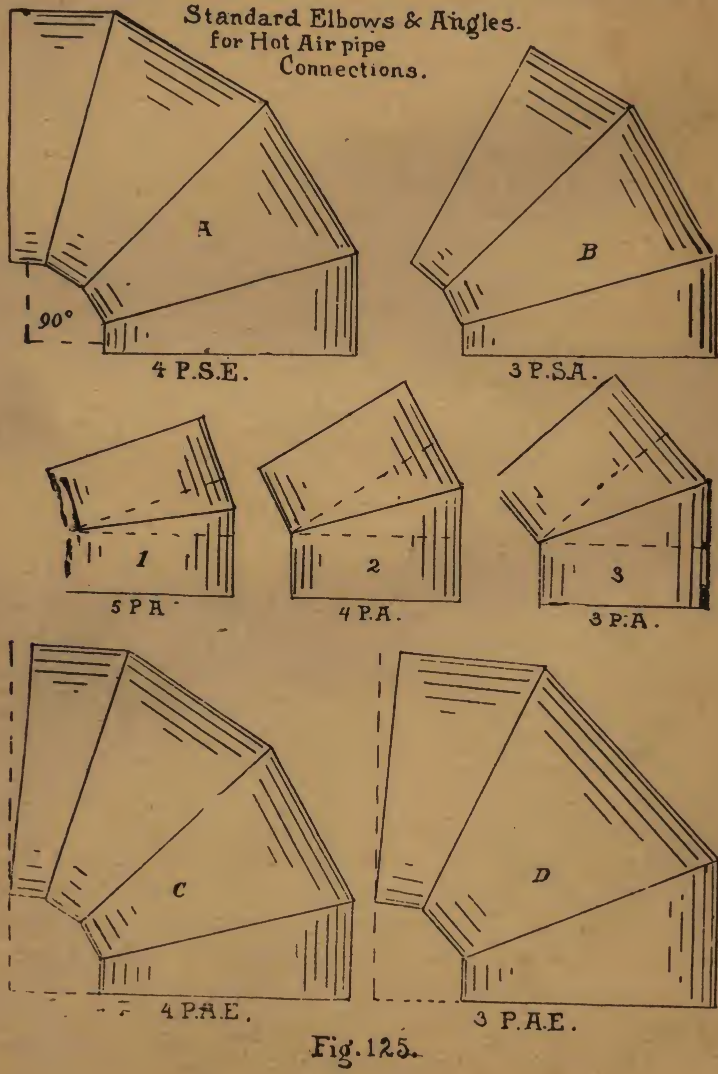


Fig. 125.

section has from a base line of the starting or first section of the elbow, in case the sections and the pitch of miter lines are the same or uniform

throughout all the sections of an elbow. In all square or 90° elbows, with the except on of a square or two-piece elbow, the first and last sections have but one height of the regular pitch added to the straight or cylindrical part of the same; all the intermediate sections have this height added

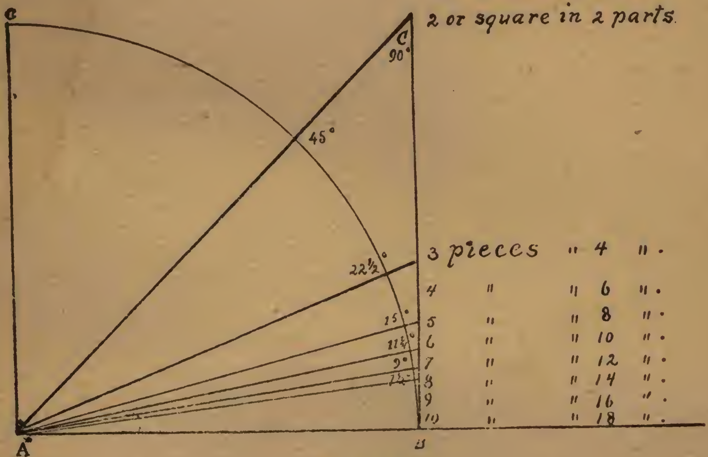


Fig. 126.

twice to their regular cylindrical parts, which is also the width that the section is for the throat in this part. The added parts, as a matter of course, by being thus added to the outside part of each section, while there is nothing added to the inner curve of the throat of the elbow, cause the same to assume the rounding or curved shape that it is intended it should have to whatever shape it is laid out and designed. Thus in a three-pieced elbow the top and bottom end each has one pitch added while the middle piece has twice the pitch added, and as a consequence, if the outer curve is described as a quadrant, we say that the same for a three-pieced elbow is divided into four parts, and for a six-pieced elbow, into ten parts, etc., etc. Fig. 126 illustrates the foregoing in all its details. The quarter-circle represents the outer curve of an elbow as from C to B. C to A and A to B are at right-angles to each other. A to B consider as the diameter of an elbow. Divide the quarter-circle into as many parts as the table gives for any elbow up to ten pieces or sections. The height that the first part will be on the line B C for any elbow desired, if divided as directed, is the point at which a line drawn from point A to the line C B must cut it when so drawn; the height so found is the highest point that the pitch of the miter line of any elbow has for which the miter line is drawn on line B C, if drawn to the foregoing directions. The Fig. 126 also gives the degree of the miter

line for elbows made from two pieces which have a 45° miter line to a seven piece elbow whose miter line has $7\frac{1}{2}$°. On the right-hand side of line C to B is given a table showing how many parts the quarter-circle is to be divided into, according to the number of sections the elbow is to have, as for example, a four-piece elbow divided into six parts, a nine-piece elbow divided into sixteen parts, etc. Fig. 126 gives all elbows that will ever be used in ordinary work that are made to an angle of 90°. In case an elbow diagram as Fig. 126 shows, is desired for off angles or elbows which are to have a rise, or the quadrant is to be less than 90°, the line A to C can be changed to suit any desired degree, all the other particulars as given remain the same with the exception that the degrees as given for the miter lines are changed to suit the occasion. The degrees given in the figure are only for right-angled or 90° elbows. As stated, an elbow, no matter what its diameter, if made of a certain number of pieces, is always made to the same miter line, that is, a 4″ elbow if made out of four pieces has the same pitch or inclination and the same degree to its miter line as an elbow which is any number of times larger in its diameter, but which has the same angle and is made of the same number of sections or pieces. This

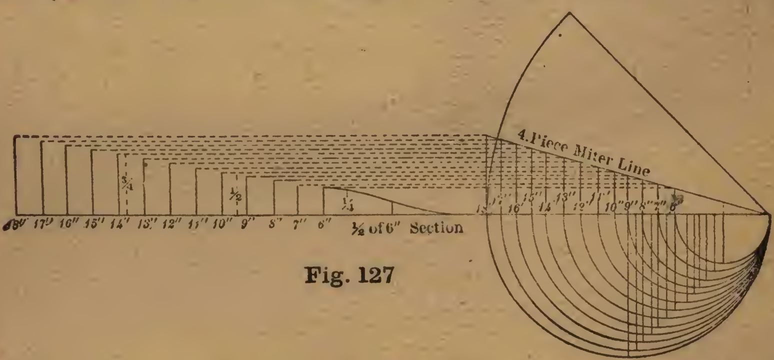


Fig. 127

unity of principle is illustrated in Fig. 127. This figure shows a four-piece miter line, how the same serves for a 6″ to 18″ elbow, and I may add could be extended to an elbow of any diameter desired. The main point shown is the center line for each of the sections, this center line being the line which divides each circumference of each section into quarters. More lines could be shown but they would crowd the drawing too much. What is shown fully demonstrates the principle involved in this exposition as given by the Fig. 127.

In Fig. 128 is shown the practical application of the various rules and adaptation of the principles referred to in the foregoing diagrams. The quarter-circle as shown from C to d gives the outer curve of an elbow,

the inner curve, of which one-half is shown by the line E to K, for the throat curve. The distance from point C to the line E K gives as divided the width of each section at the inner curve. If the throat curve were even nearer to the point C and also the outer curve relatively moved nearer to this point C, the miter, as a matter of course, would not change, no matter into how small a curve the elbow was made. The only change that would occur would be that the width of the throat in each section would be reduced according to the proportionate distance that the curves are moved

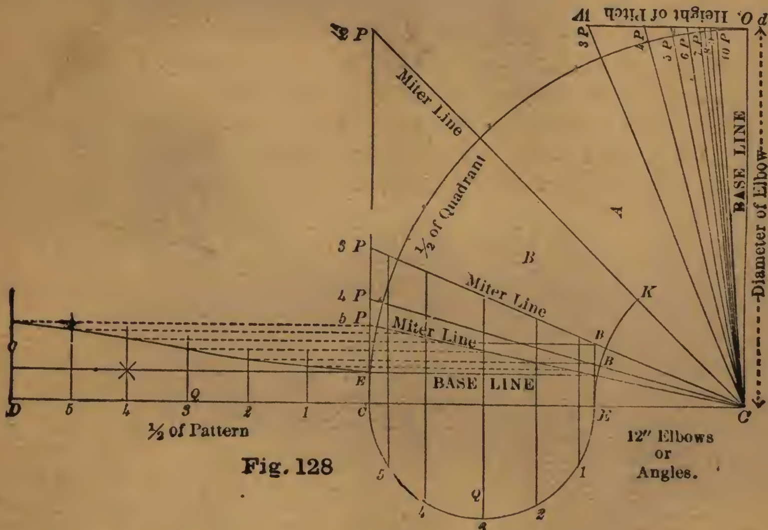


Fig. 128

nearer to the point C. Taking the figure as shown, I will say that it is intended that a 12″ elbow is required to be made in five pieces. As will be noted the curve is divided as demanded for this number of parts; underneath the line D to C is drawn the half-circle or half of the circumference of the elbow. Divide this into any convenient number of parts, the more the better and the easier it is to obtain the true curve that the miter line will develop on the stretch-out when the pattern for the elbow is fully drawn. Erect lines from points 1 to 5 from semi-circle as found to the miter line for the elbow demanded; transpose these distances as found to the lines as shown in the stretch-out X. One-half of stretch-out is only shown in this figure. The dotted lines show one method to develop the true height of the various lines. Another method is to use only the upright lines for this purpose by transposing the distance on each line between the base line and miter line to the line corresponding on the stretch-out, to the line from which the measurement is taken above the

semi-circle. The same operation is done for any pattern desired for either of the other elbows, no matter how many pieces it is intended the same should be made out of, only observe that each operation is done as it should be so that each set of lines is correctly transposed as demanded. It will be observed that the stretch-out will answer for any number of pieces it is desired the elbow should be made from, if the diameter of the desired elbow is the same, the only difference being in the height of the pitch of the miter line and also its curve on the stretch-out for the various sizes of elbows. On the right-hand side of the center line in Fig. 128 is shown the hight of the pitch of each miter line fully drawn out, which shows how the operation is done to obtain the result. Now in order to facilitate the quick and accurate determination of the correct height of the pitch which each miter line has for any size elbow from one to twenty-five inches in diameter and from a two-piece or square elbow to one made out of ten sections or pieces, the following table has been prepared:

DIAMETER IN INCHES.	NO. OF PIECES IN ELBOW.								
	2	3	4	5	6	7	8	9	10
1	1	15/32	9/32	7/32	6/32	5/32	1/8	1/8	3/32
2	2	27/32	18/32	13/32	11/32	9/32	1/4	7/32	6/32
3	3	1 1/4	13/16	5/8	1/2	7/16	11/32	5/16	9/32
4	4	1 21/32	1 1/16	13/16	21/32	9/16	15/32	13/32	3/8
5	5	2 1/16	1 5/16	1	13/16	1/16	9/16	1/2	7/16
6	6	2 1/2	1 5/8	1 3/16	31/32	3/16	11/16	5/8	9/16
7	7	2 29/32	1 7/8	1 3/8	1 1/8	5/16	13/16	9/16	5/8
8	8	3 5/16	2 1/8	1 9/16	1 1/4	1 1/16	29/32	13/16	23/32
9	9	3 23/32	2 13/32	1 13/16	1 7/16	1 3/16	1	29/32	13/16
10	10	1/8	2 11/16	2	1 9/16	1 5/16	1 1/8	1	29/32
11	11	4 1/2	2 15/16	2 3/16	1 3/4	1 7/16	1 1/4	1 3/32	1
12	12	4 15/16	3 3/16	2 3/8	1 7/8	1 9/16	1 3/8	1 3/16	1 1/16
13	13	5 3/8	3 7/8	2 9/16	2 1/16	1 23/32	1 15/32	1 5/16	1 5/32
14	14	5 3/4	3 23/32	2 3/4	2 7/32	1 7/8	1 9/16	1 3/8	1 1/4
15	15	6 5/32	4	2 31/32	2 3/8	2	1 11/16	1 1/2	1 11/32
16	16	6 19/32	4 1/4	3 5/32	2 17/32	2 1/8	1 13/16	1 19/32	1 7/16
17	17	7	4 7/32	3 6/16	2 11/16	2 1/4	1 15/16	1 11/16	1 1/2
18	18	7 3/8	4 25/32	3 9/16	2 27/32	2 3/8	2 1/32	1 25/32	1 19/32
19	19	7 13/16	5 1/16	3 3/4	3	2 1/2	2 1/8	1 7/8	1 11/16
20	20	8 1/4	5 5/16	3 31/32	3 3/16	2 21/32	2 1/4	2	1 25/32
21	21	8 5/8	5 19/32	4 5/32	3 11/32	2 13/16	2 3/8	2 1/16	1 7/8
22	22	9 1/16	5 27/32	4 3/8	3 1/2	2 15/16	2 1/2	2 3/16	1 15/16
23	23	9 7/16	6 3/32	4 9/16	3 21/32	3 1/16	2 19/32	2 9/32	2 1/32
24	24	9 7/8	6 3/8	4 3/4	3 13/16	3 3/16	2 11/16	2 3/8	2 1/8
25	25	10 9/32	6 5/8	4 15/16	3 15/16	3 5/16	2 13/16	2 7/16	2 3/16

The table is adapted to right-angled elbows only. The line of figures

at the top of the table indicates the number of pieces of which elbows are to be made. All other figures are in inches, the first or left-hand column being the diameter of elbows, the remaining columns being the height of pitch required.

As will readily be seen this does away with the necessity of drawing the entire diagram every time it is desired to obtain the height of the pitch of any certain miter line for an elbow. The height of pitch for a three-pieced elbow is shown as indicated by O to W in Fig. 128 and is given in the table in column 3. In two-piece elbows the hight of pitch is the diameter of the elbow, and this column is added to make the table complete. No matter how large the sweep of an elbow, the angle of pitch remains the same, and the only difference to be made in cutting the pattern is to add space as desired for the throat. Locks and seams are to be added.

Fig. 129 shows a rule or method for different angles, or the rise for the elevation of elbows. As has been stated before, the rise usually given

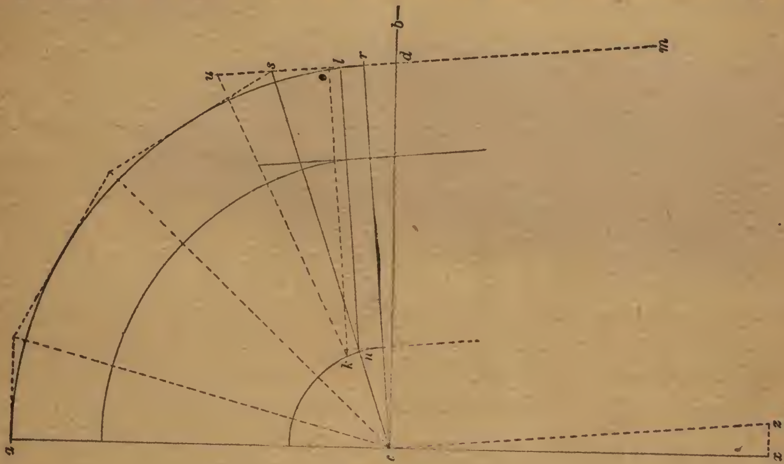


Fig. 129.

to furnace pipe elbows is one inch to the foot. The method given is as follows, and is applicable to any size throat or any size elbow, and to elbows with any number of pieces: First draw lines a c and c b, of Fig. 129, at right-angles to each other. From point c, on line c b, measure off one foot, and perpendicularly from the point thus obtained erect line d to r, which is the desired height for the elbow to rise, or angle from a true right-angled elbow—in this case, one inch to the foot.

From point c as center draw the arc a to r. From point r draw the line r c for base line. This will give the correct elevation, as proof clearly

shows by the dotted lines c to z and r to m; these show the continuation that the elbow leads to, namely as in this instance 1 inch rise to the foot or 1 foot in 12 feet. The line c to x is one foot and from x to z, one inch.

If an elbow of four pieces is desired, divide the arc or curve r to a into six equal parts; if an elbow of three pieces or sections is wanted divide same into four equal parts. From point c for a four-piece elbow, draw line c to s, and from point n, where inner curve of elbow intersects line c s, draw line n to l parallel to line c r, and same intersecting line r s at l. This gives us the pitch and rise for miter line for a four-piece elbow of the desired elevation. For a three-piece elbow the dotted lines from point k on the inner curve to points u and o on outer curve give the miter desired.

I have also made a smaller sized elbow in the drawing to show how the rule works and is applied on same. It is, of course, not necessary to give the same size of throat as is given in the drawing nor the same outside sweep. This rule will suit any case or sized elbow as may be desired, and as one becomes familiar with the working of the rule, some of the other lines need not be drawn out, but are here given to make the drawing complete.

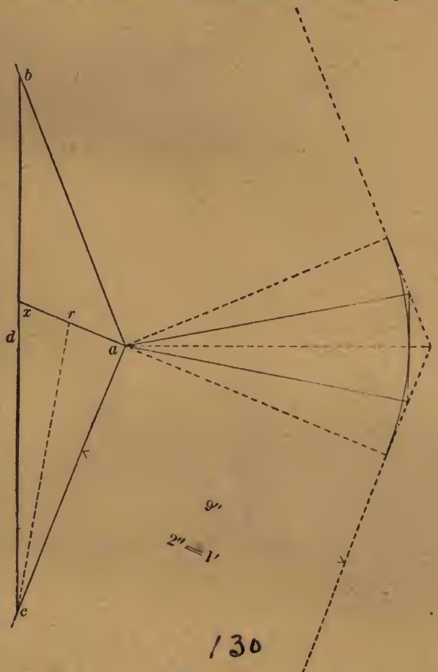
The above is given to get the complete data for side elevation which are necessary to develop the patterns for the different sections of an elbow. In this instance it may be allowable to introduce a so-called snap rule to develop the stretch-out. I have often used it and found it very handy, especially when in a hurry.

If Fig 130, is examined, it shows the usual long and tedious geometrical method of obtaining miter lines for both a two-piece and also a three-piece angle, both of the angles being of the same pitch. The solid lines are for a three-piece angle, and the dotted lines are for a two-piece angle.

Now to do away with all this drawing, and to get a quick and very nearly correct method to obtain the desired result, suppose an angle is wanted as is given by the lines a to b and a to c, Fig. 130, the diameter to be as full drawing requires, proceed as follows: First measure off the distance which is the size of the diameter wanted, from a to b; do the same from a to c, and from points thus obtained, which are c and b, draw the line d from c to b. Then from either line a c or line a b draw at right-angles the line a to x as shown, the line a x intersecting line d at x. This gives the required elevation for miter line of a two-piece angle as called for; line d from c to x is miter line, a to x its height of rise, and a to c base line, which is size of diameter called for. The line x to a divided into half gives the point r where the miter line intersects, of a three-piece angle; r to a is height, a to c is base line, and c to r is miter line, as will be seen by dotted line in drawing. Twice the length of distance of line from points a to r is

the width of outer curve of center section. You must, of course, allow for laps or burrs for joining same together when cutting pattern.

Compare this with the solid center section of full side elevation and see how much quicker this method is than the old way. When once accus-



130

Fig. ~~10~~. 130

tomed to use this method you will use no other. This rule is absolutely correct for a two-piece angle, and varies so little on a three-piece angle from being absolutely correct, that the variation is practically of no moment.

To develop the stretch-out, Fig. 131, lay out the full length of circumference, as is shown from a to b,and divide this length into six equal parts as in drawing. Make the center line, No. 2, same height as required, as in this case for the two-piece angle of Fig. 130. Next divide the right and left lines nearest to the center line into four equal parts, and mark off one of these parts nearest to the top of each line; do the same as to spacing the lines nearest to the end of stretch-out, as lines No. 4 and r, but with the difference that you mark off one space at the bottom of each line as the drawing fully shows. Continue the center line indefinitely downward and with dividers strike the arc 1, 2and 3, cutting lines at points 1, 2 and 3.

Draw line b indefinitely upward, reverse the dividers, and with line b as center line draw the arc from point 5 to point 4, cutting points 5 and 4; do the same on the other end. Then draw a straight line from point 3 to 4, and same from 1 to r. This completes the pattern. Allow for locks or laps on both ends and miter lines, of course.

The method given in the foregoing may also be applied for the development of a full elbow, but where absolute accuracy is desirable I would advise to use the strict geometrical rule.

Having shown how the preliminary data and necessary drawings are

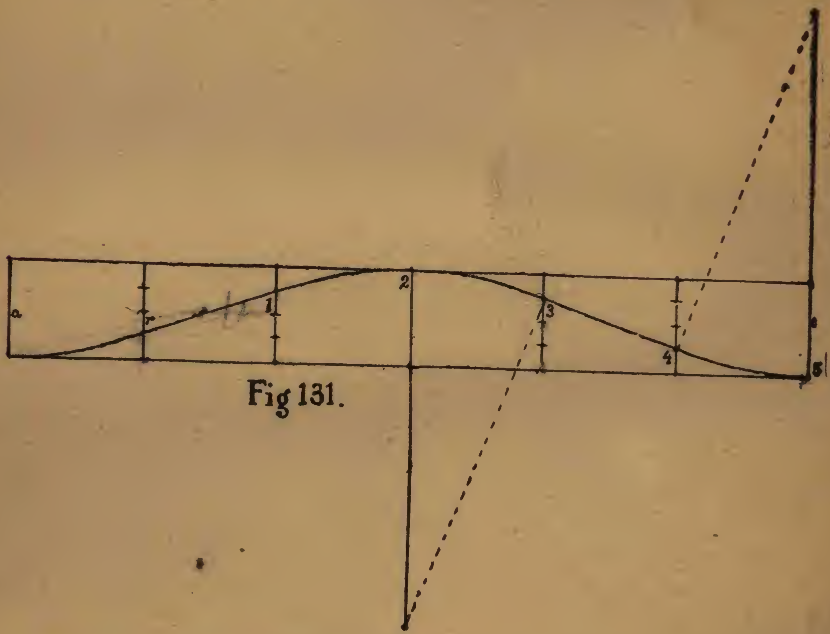


Fig 131.

made and developed for elbows in general, the next step is to determine out of what size sheets the elbow is to be made. This determined, the material is to be cut the right length for the stretch-out or, in other words, the circumference as demanded for the size elbow desired. In some shops the sheets are joined and grooved together and the right length obtained. The entire elbow is marked out, cut and then formed into shape as desired. Then again it is the custom in other shops to have separate patterns for each section, and if it takes more than the length of one piece for the circumference, two separate patterns are used for each section, these marked off on the material, the separate pieces are formed into the proper shape so

demanded, then the pieces are folded for locks, and after all this is done the two pieces of each section of the elbow are joined and grooved together.

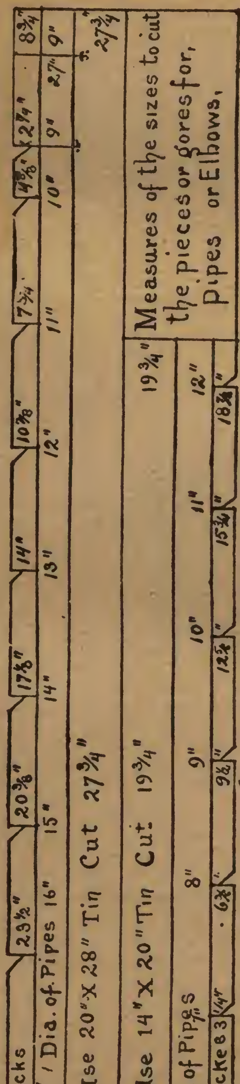


Fig. 132.

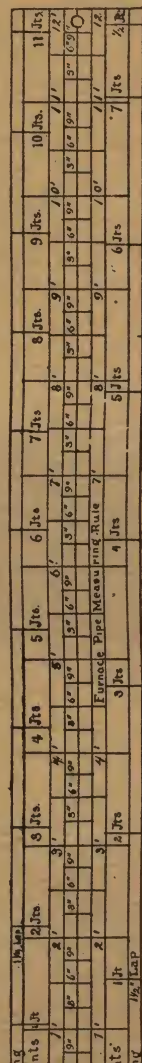


Fig. 133

The foregoing gives in detail the two methods that are mostly used to accomplish this part of the work on an elbow. I am of the opinion that the

first described method is the easiest and quickest way of doing this work, although I have worked both ways. Some workmen whom I have seen would use no other way for this work than the last described method, and actually could do better and work faster than they could by using the other method. It depends upon how one happens to take to a certain way of doing work of this kind of elbows. I have given both ways; the student has the choice. I have often seen cases where workmen, even if shown a better and simpler way to accomplish a certain task, if they did not readily take to the method shown them, or perhaps unwillingly adopted the same, would or could not do as well as if they had been left to their own favorite way of doing the work. As I have stated before, some shops use only 20″x28″ tin for this class of work, while others use nothing but 14″x20″ sheets. In either case, whatever the sizes used in a shop, the circumference of any certain size pipe and elbows are as a matter of course the same.

In Fig. 132 is shown one of the handiest circumference rules that ever came to my notice. As will be seen, it is adapted for both 14″x20″ and 20″x28″ sheets. It can be made of wood, iron, tin or steel, as the workman cares to have it, or according to the amount of money he cares to spend for one. If made of wood, make it about 3-16 of an inch thick, about two inches wide and $27\frac{3}{4}$ inches long, or as long as is customary to cut the sheets when squared. The length given is what this rule is figured at. If the 20″x28″ sheets are used, the full length of the rule is for the full sheet, while the figures (say for 12″ pipe) for the gore or small piece of tin are $10\frac{7}{8}$″; thus $27\frac{3}{4}+10\frac{7}{8} = 38\frac{5}{8}$″ = circumference of a 12″ pipe, 1″ allowed for two locks. For a full size 9″ diameter pipe or elbow, cut large sheet 27″ as shown and gore $2\frac{1}{4}$″; thus 27″$2\frac{1}{4} = 29\frac{1}{4}$ = circumference of a 9″ diameter pipe, 1″ allowed for two locks. Two sheets cut the full length of a $27\frac{3}{4}$ measure make a joint $17\frac{3}{8}$″ diameter. The other figures explain themselves for the sizes shown. This for the side which has the measurements for 20″x28″ tin. The measurements as shown for 14″x20″ sheets are the sizes to cut the material for the large piece $19\frac{3}{4}$ and the gores as shown, as for 7″ diameter, $3\frac{1}{4}$″ for 10″ diameter, $12\frac{5}{8}$″, etc.

A suitable hole to hang this rule up may be put in on one end as shown. If made of wood the lines and figures may be marked on the rule with ink or branded as deemed the most suitable. If of tin or iron, etc., the lines may be marked with a scratch-awl, or etched, as well as the figures. Another handy rule made in the same style and manner as Fig. 132 is shown by Fig. 133. This measuring rule gives the length of pipes in sections for both 14″ and 20″ joints. It gives the length of pipes made out of sheets the 20″ way up to $7\frac{1}{2}$ joints, each joint lapped $1\frac{1}{4}$″. Pipes if made the 14″ way and $1\frac{1}{4}$″ lap are shown up to 11 joints. The three

spaces in the center show the number of feet the joints measure; each foot space is divided into 3″ divisions. This rule can be made to any scale, and for that matter as long as desired; that is, the measure for any num-

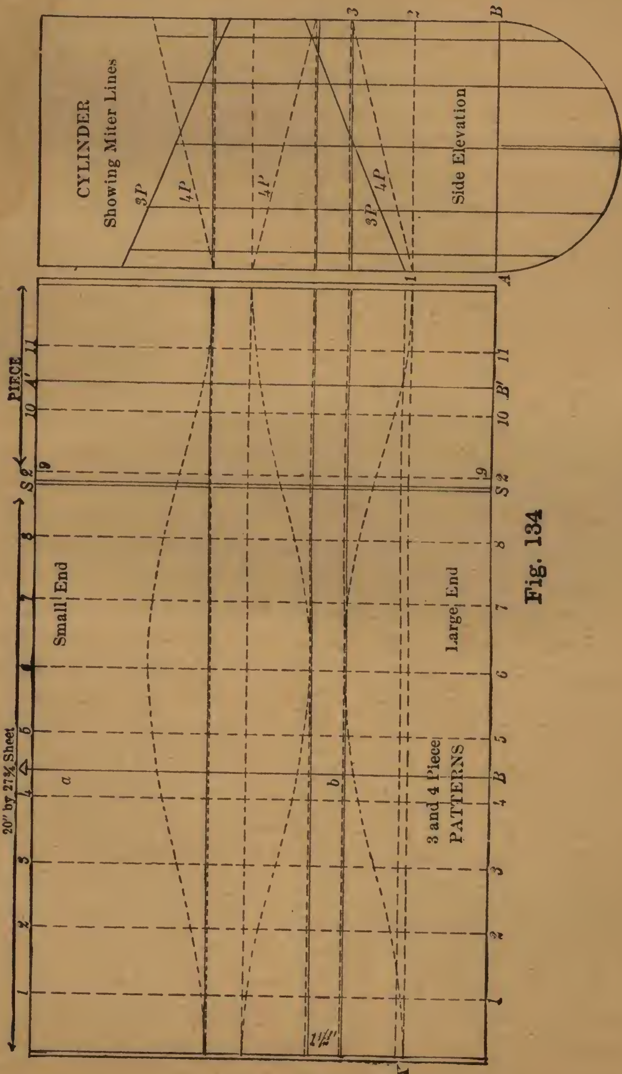


Fig. 134

ber of joints can be shown if so desired. The most convenient length for a rule of this kind is, for shop use, 36″ long or 3″ to the foot, 2″ wide, and

the thickness according to the material it is made of. These styles of rules are two of the most useful tools that could be devised to perfectly answer the purpose that they are designed for. The Fig. 133 is drawn $\frac{1}{2}''$ to the foot. I would advise that one or two of each kind be provided in each shop where furnace work is done, as their cost is only a trifle compared to the time and figuring which they save. Having all the details arranged, I will assume that it is intended tomake the patterns for an elbow out of sheets of 20″x28″ tin. The Fig. 134 shows the patterns for both a four-piece and for a three-piece elbow complete. The four-piece elbow miter lines are shown by the continuous dotted lines, while the miter lines for the three-piece elbow are shown by the solid lines 1 and 2. I will assume that the patterns are for 10″ elbows. In this case the large sheet is cut $27\frac{3}{4}''$ by 20″ and is shown on the left of the grooved joint S, 2′ S, 2. The piece is cut $4\frac{5}{8}''$ by 20″ Center lines are shown for both the large piece as also for the smaller one, but are really not needed when the patterns are laid out by this method.

In actual work, the width that the gore or inner curve is made is generally from $1\frac{1}{4}''$ to 2″ wide for each section. This is shown in this drawing at $1\frac{1}{2}''$ for the four-piece elbow; for the three-piece patterns no particular width has been figured on, but it is shown in the drawing as it is, so as not to interfere with the miter lines of the four-piece elbow patterns. The extra side elevation gives the shape which the cylindrical envelope of an elbow would present if all the patterns had first been drawn out in the flat and then formed into the cylindrical shape as it is here presented.

This operation is really all that is done when the drawings for the data from which the patterns are deducted are made but reversed. The elevation gives all the miter lines of both a three and four-piece elbow, and shows the correct position which each section of an elbow has to the other before it is cut out of the sheet. After this is done the pieces are reversed and the new position which each section assumes by reason of being thus reversed, causes it to have the shape of an elbow as the finished article presents. In this drawing, Fig. 134, the line 1 to 2 of the elevation is the base line; from point 2 to 3 is the height of pitch, and from point 1 to point 3 is the miter line demanded for a four-piece elbow. The height of this side elevation is assumed to be 20″, and it is so arranged that each section has a space of $1\frac{1}{2}''$ for the inner curve; that is, the two sections next to the end sections are thus provided for, while the two end sections each have a much longer space allowed in order to provide and enable the same to slip over and into other similar cylindrical-shaped pipes for the purpose of making a firm and solid connection. How much to allow for every case of this kind when designing a pattern for an elbow is usually a

matter of individual choice with the person who is designing it. It is desirable to have at least two inches of lap for either end; three inches is the usual allowance for this item. In order to get the outline of the curve that the miter line has on the stretch-out, draw the semi-circle A to B on elevation; divide this curve into as many parts as desirable. In this case it has been divided into six equal parts. Erect lines as shown, then divide the stretch-out into twice the number of spaces that the semi-circle is divided into. Draw the lines as shown by the numerals 1 to 11, then draw

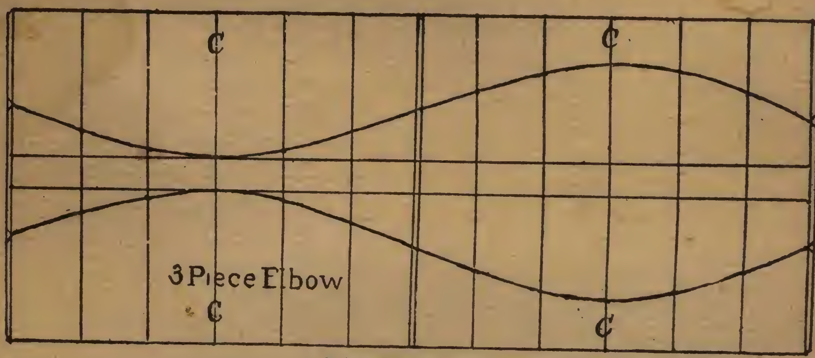


Fig. 135.

the line 1 to X for base line; transpose the distances that the lines have in the elevation between the base line and miter line to their respective corresponding lines of the stretch-out; when this is done for all the lines, trace or draw the miter line for the curve through the points or positions as found, and the pattern for this section is done. Do the same for each section of the entire elbow as desired. The foregoing applies for both elbows as shown. It is understood that the foregoing operation is applicable to to all styles of elbows which have an equal diameter throughout, no matter if the elbow is a right-angled or 90° elbow or only an off elbow, or even a two-pieced angle. The same arrangement as has been shown for sheets that are 20″x28″ can also be followed for 14″x20″ sheets, as far as this size tin will allow by using the tin the 14″ way for height and the 20″ way for girth or circumference of the elbows. Fig. 135 shows another arrangement sometimes made use of when the sections of elbows are drawn out and patterns are made for them. The idea in this case is to have the center of both the widest part of the sections as well as the narrowest come directly opposite each other, so that no cross-seam of the elbow is located either at the center of the throat or at the extreme widest part of the outer curve of the elbow. This style elbow presents when finished all its cross-

common elbow has. This miter line as shown by curve C has only been developed to the stage described so far for line B, of Fig. 139. The same changes and consequent methods that are used for line B will also apply for line C, with the difference that they have to be suited to the conditions as presented by the position C of Fig. 138, for which the line C of Fig. 139 gives the miter line.

The first fact that must be considered in connection with line B of Fig. 139 is this—that the position which the outlet of the elbow assumes by position B makes it necessary that the sections be made longer so as to reach the new positions with their end terminations, which they assume by

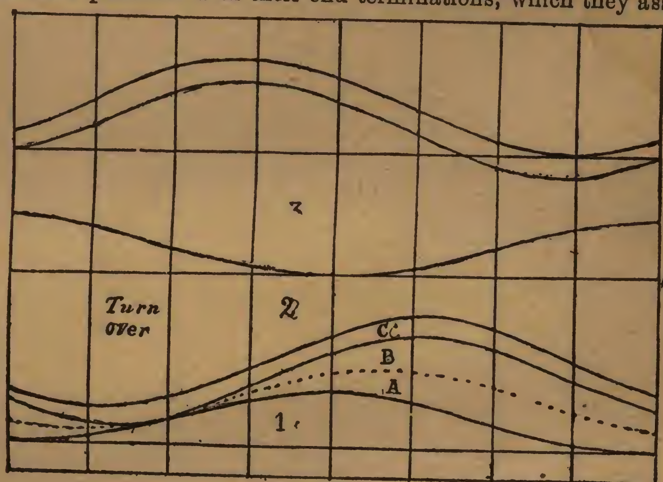


Fig. 139.

reason of this change from a normal position as shown by A′. This is shown by the distance from S to X′ on line 3 to S. This distance must be added above line B of Fig. 139 to the section 2, either to line B or to the center miter line of the elbow itself. Another consideration that has to be met in this problem is, that by reason of the altered positions which the different sections assume by the alteration of the normal outlet of the elbow, the miter lines have a little less pitch than they would have if the normal shape of the elbow had not been disturbed from that of a common straight-away curve. The difference that this change occasions is equal to the distance as shown from point S to X′ of Fig. 138 in this case. Add one-half of this distance to the pitch of the center miter line of both the sections 2 and 3 when finally laying out the stretch-out. This will give the elbow the perfect curve desired. The same conditions also apply to the entire operations for the patterns of the position called for by C, modified

to the extent, that the measurements as that position demands be complied with. The stretch-out as shown by the Fig. 139 has only been drawn out as far as the first step described goes; the final additions to the various curves have not been shown. I leave this to the student to work out himself, as it is comparatively a trifling matter, and as the whole problem drawn out would only cause confusion of lines in a drawing so small as that shown here.

The Fig. 140 shows five separate and distinct styles of miter fastenings to join the sections of elbows together.

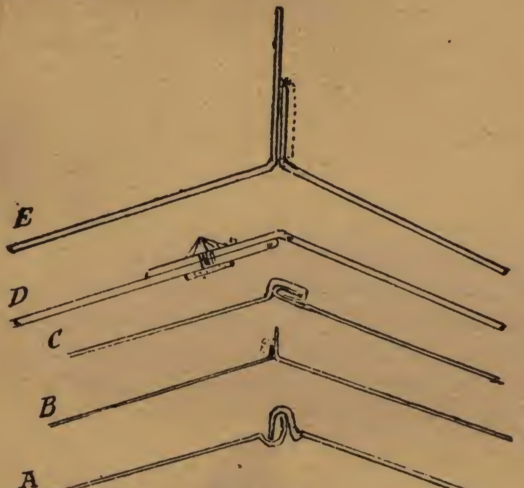


Fig. 140.

The styles as shown by A, B and C are used for tin elbow fastenings. Of these B is the most used method and is, as the drawing shows, a burred edge overlapped by a wider edge and this pinned down by hand or a setting-down machine. This joint is what is usually called a pinned-down joint. The dotted line shows how the wider edge is bent over on to the narrower one and there made fast, as described. This style of fastening is generally used on the smaller sizes of tin elbows up to 10″ in diameter. The smallest burr is turned out about 3-32″ while the large edge is made to correspond, so that when turned over a good and perfect lap is effected. When the elbow is finished the various joints are tacked with solder at two or three places around the circumference of the joints.

The fastening C, as shown, is a double-seamed joint and is substantially the same as joint B, only that to make this joint the workman has to go one step farther in addition to all he had to do for joint B. and that is, he

has to hammer the joint over and down smoothly as shown. This operation is mostly done with the larger size elbows. This joint in itself is one of the strongest joints or fastenings used for this class of work on tin elbows, but I may add that an elbow when finished by this method is not nearly as stiff and solid as it would be if made with the joint B as described. This is due to the stiff and unyielding shape the joint B is made into, while the joint C, when it is once hammered down, has nothing to back it up so that it will not yield to outside pressure. One of the neatest and at the same time one of the most difficult joints to make on tin elbows is the style shown by A, Fig. 140. This method is by using the turning-machine to make the shape of the bends as shown. This shaped fastening enables one to turn each section of an elbow thus made, so that it is virtually a reversible elbow. Every furnace man knows how handy such a feature in an elbow sometimes is when putting up pipe and elbow connections and only a slight turn is desired, which cannot be made with solid jointed angles as the other styles have. I may also state that this style of joint makes the elbow very stiff and strong. It is of course necessary that the joints are tacked as described for style B.

The method shown by D is the usual joint used for sheet iron, steel, etc., for elbows of both the lighter as well as the heavier grades of material. This joint is called a riveted joint; the lap, a rivet and manner in which it is put together are all plainly shown in the drawing. In some of the heavier jobs the joints are first coated with either red or white lead, asbestos or putty, and are then put together and riveted. The usual mode of making an elbow of the heavier gauges of iron is as follows: First lay out the various sections needed for the elbows; be sure that enough material is allowed for the lap of each joint to each section as needed; then form the sections into shape as wanted and rivet the cross seam of each. Now prepare the first section of the elbow, which is the large end of the elbow, by turning the edge inward to the extent of the lap that it is intended the joints should have; then turn the edge of the next section which is to fit over section one outward on its inner or throat side. Draw in and stretch out the two sections until they fit perfectly and have the same lap all around as desired; then punch the rivet holes in the outside section, place the same on to the first, or section which goes into the section two, and mark the rivet holes on section one. Take off section two, punch rivet holes through section one, then put both together again and rivet the two together. The same operation has also to be done for each joint in the elbow, they are all finished in the same way as described for joint one. The foregoing method is used for a heavy iron elbow which has its joints between the sections riveted together.

The method used for fastenings, as shown by E of Fig. 140, is substantially the same as that used for B, only on a larger scale in heavy work. The edges are heated and then turned over a square-cornered stake with a hammer. The last edge, as at F, is generally turned with the iron or steel cold. It is understood that this requires skill, good judgment how to manipulate the iron during the operation of turning the same, and last, it requires first-class material with which to do a job of this kind. Common grades of iron will not do for work of this kind. Use nothing but the best Juniata stock or soft steel for this purpose.

In the following are given descriptions of some handy tools for elbow work.

Fig. 141 shows two styles of casing-knives used to open seams, lock joints, etc. One style is shown by A with two flattened end edges, while

Fig. 141.

the style B has the blade flattened at one end only. This style is provided with a wooden handle. These are very serviceable tools, in fact, are necessary to the workman if fast work is demanded. They are made of steel. Any old file $\frac{3}{4}''$ wide by $8''$ long; will do if it is about $\frac{1}{8}''$ thick, to make either tool of. Draw out the two ends as shown, bent slightly at the ends with a very thin edge and tempered so that they will stand the wear

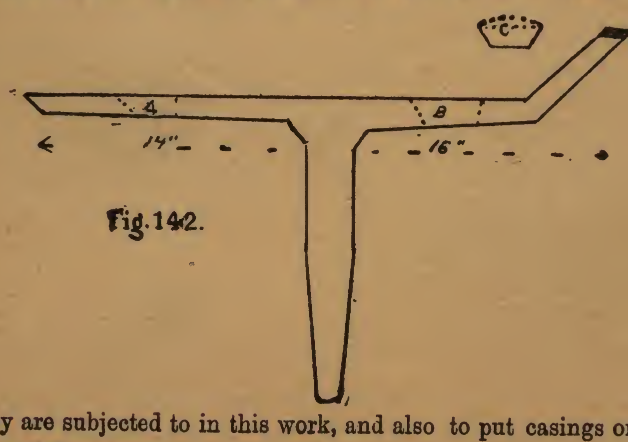


Fig. 142.

that they are subjected to in this work, and also to put casings on the casing rings of furnaces.

Fig. 142 shows a shape for a very handy stake in use in some shops to

set down seams, etc.,in this work. All particulars as to how it is shaped are fully shown in the drawing, also all measurements needed so that a model of wood or of tin can be made and from this, one can be cast of iron. If one is made of cast-iron, the edges can be smoothed by filing or planing to make the stake suitable for fine work; further comment as to the usefulness of this tool would be superfluous; its worth is at once apparent to the student.

Fig. 143 shows the two wheels of a setting-down machine as ordinarily made. It is known to all furnace men that the bulge outward on the upper wheel A is one of the most troublesome hindrances that could be devised to the easy setting-down of the seams on elbows; particularly is this

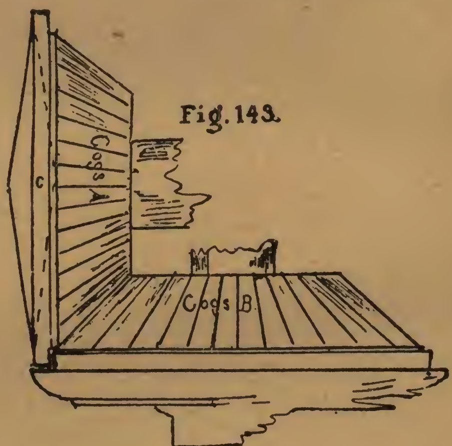


Fig. 143.

the case when that part of the seams is to be set down that is at the throat part of an elbow. To remedy this, I would advise that the upper wheel be taken out and the chunk be turned out as far as the dotted line C shows in Fig. 143. This will be found a great improvement over the style shown by the solid face as it now is in these machines.

In Fig. 144 is shown a front and side view of a pinning-down hammer. As will be seen by the drawing, the front and the left-hand side pane of the flat of the hammer have a slight projection out from the body; this feature and the delicate outline of the entire tool make it the best shape that could be devised for the purpose of setting down seams. The drawing gives a half-size view of the hammer. A tool like the drawing shows will have to be made by a blacksmith, as it seems that the manufacturers of tinners' hammers have not as yet arrived at that point where they design tools of this class, or that the best shape, the comfort or the convenience and

wishes of mechanics who really use this class of tools are consulted. It appears to me, to judge by the samples of hammers on the market, that the roughest, clumsiest and most unhandy shapes are the kinds offered to mechanics to work with. If a more suitable tool is desired, all the workman can do is to have it made to suit himself by some blacksmith. To help those who really desire the proper shape so that good, neat and fast work can be done by workmen, I submit the shapes as shown.

Fig. 145 gives two one-third-size drawings as to length of another style of pinning-down hammer. In some cases one end of this hammer is

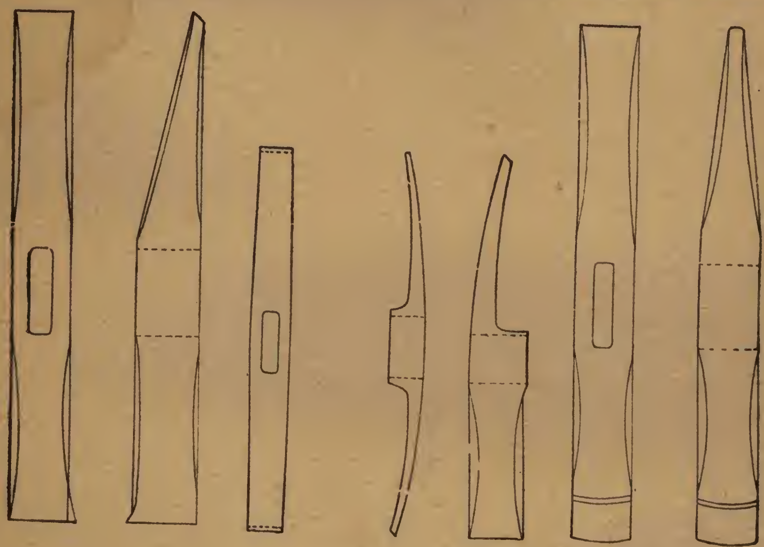


Fig. 144. Fig. 145. Fig. 146. Fig. 147.

sharpened and is used as a cutting tool to cut pipes, etc. This tool may be made one inch wide, face view. Fig. 146 shows a one-third size view of a setting-down and riveting hammer. This is a very handy tool. Fig. 147 is a front and side view of a very fine riveting hammer. This drawing is half-size of the desirable size such a hammer should be. Fig. 148 shows two views of a good riveting, flanging and stretching hammer. This style can be made to suit the workman, as also can the flat and ball-face hammer, as shown by Fig. 149. Fig. 150 shows one of the most useful and handiest tools used about a furnace-shop for sheet-iron elbow work. It is made of cast-iron; all the measurements are given in the drawing. This tool is handy to hammer down the inside edges of sheet-

iron elbows, the joints, etc.; in fact almost any part where a hammer cannot be conveniently used, this is just the tool required to get at the work.

Three other useful styles of hammers are shown by Figs. 151, 152 and 153. The hammer shown by Fig. 151 is a long, slender riveting hammer.

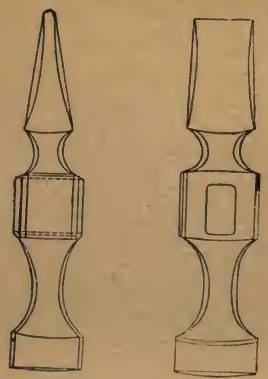


Fig. 148.

Fig. 149.

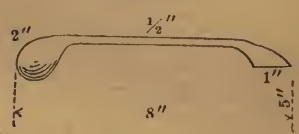


Fig. 150.

This style is a great favorite with some workmen. It is about 7″ in length and about 1″ square at its largest part where the eye for the handle is. The drawing shows its general proportions.

Fig. 152 illustrates a front and side view of a neat and serviceable flang-

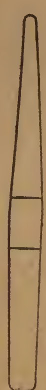


Fig. 151.

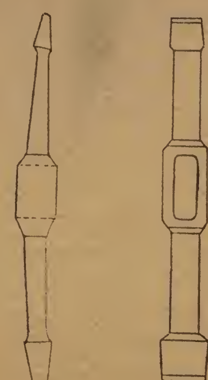


Fig. 152.

Fig. 153.

ing hammer. It is usually made from $5\frac{1}{2}''$ to $6\frac{1}{2}$ long,″ other dimensions in proportion, as the drawing shows. Fig. 153 is a somewhat heavier rivet-

ing, flanging and flat-face frame hammer. The length is usually 6″ long and is made in weight to suit the fancy as well as the requirements.

A few words as to the general finish and care of a kit of hammers. It will be noticed that wherever practical the hammers as shown in the drawings have the sharp edges neatly chamfered out at the sides, etc.; this gives to these tools a neat appearance and on some hammers adds to their practical usefulness in so far that it entirely obviates the possibility of these edges injuring work, which they often do where they are sharp edged and not finished as shown in the drawings. This half-finished feature is almost in every case the property of nearly all styles, shapes and kinds of tinners' or sheet iron workers' hammers now in the market. In contrast to this fact, see the tools used in most all other trades—for instance, the machinists' hammers. See how well balanced and correctly proportioned they are in every detail conceivable to meet the requirements of a perfect tool for which they are intended to be used. Then the carpenters' hammer. It will be sufficient to state that to bring this tool to the high state of perfection as to the shape which it has at the present day, Maydole has devoted his inventive genius and a lifetime of study. The result is a perfect hammer for the purpose. It would seem that in our trade a lot of old scraps, shaped somewhat in the form of tinners' hammers, had been thrown into the tumbling box of some foundry and the result, when these had been tossed and mixed together for a short while, is the tinners' hammer as it is. The only remedy seems to be for mechanics to have their hammers made by a blacksmith. The shapes as shown are some of the best for the purpose as described. When so made, have them polished up, then do not allow every material butcher (the term is applied to rough and botchey workmen), to use your tools. I have seen cases where green hands have taken light, sharped-edged setting-down hammers (whose faces were smooth and level and only intended for delicate material, such as planished copper and for neat smooth work), and used them on rough castings; in fact, ruined them so that they were useless for the purpose of doing smooth work thereafter. The foregoing aptly gives force to the point that when good and proper tools are provided for workmen to work with, which by the way, are the only kind with which quick, smooth and accurate work can be done, have only such men to work as will appreciate and take proper care of the tools that are entrusted to them to use. In no branch of furnace shop work is it so necessary that every tool, machine and condition be just right to accomplish a fair amount of well-done work in a certain length of time as in elbow work. The average quantity of elbows for a day's work in shops usually is from two dozen to two and a half dozen 10″ or 12″ four-piece elbows, but I have seen men who have and

do turn out three dozen well-made four-piece elbows in four and one-half hours' time. It is needless to say that these men have every tool and machine used for the purpose as they ought to be, that is, just right, and as a consequence can achieve a great deal more than others who are perhaps as good mechanics otherwise, but who have not their tools in as good a condition. The other and most needed appliances for elbow work are pliers and a prick-punch to punch through the cross-seams of the sections, so that they cannot come apart while the sections of the elbows are being joined and fastened together. Marking awls, etc., etc., are found in all shops and no special mention is necessary of these in this instance. The main aim should be to have all tools in such shape and condition that the best possible results can be obtained with their intelligent use by competent workmen.

The next style of elbows which are described in the following are tapering elbows, such as have a larger area at one end than at the other, or smaller end. The inlet, or, *vice versa*, the outlet is either smaller or larger than the other end of the elbow. In Fig. 154 is shown a combination of two cylindrical-shaped parts united by a tapering section as A shows, forming what may be termed a double-angle or tapering elbow. The method that is shown in this figure to develop the required pattern for the center section A is one which is shown in almost all of the so-called

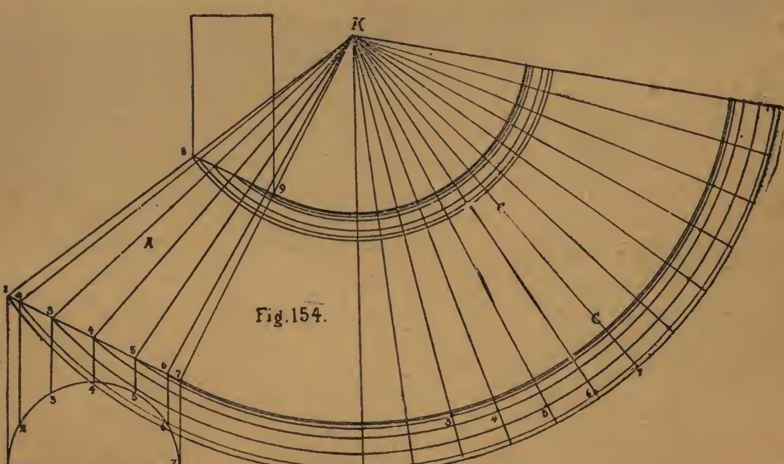


Fig. 154.

pattern books for tinners. By this method it is attempted to show how to lay out the envelope for the shape A by following the time-worn and the much misused as well as misapplied method of using the envelope of a cone to accomplish the correct solution of this problem. The first step

advised by these books generally is to draw the semi-circle 1 to 7; divide this into as many parts as desirable as shown, erect lines to the dividing line 1 to 7 between the large cylindrical part and the tapering section. Then draw lines from points 1 and 7 to point K; these lines as drawn, if they cut points 8 and 9, will establish the position of point K as shown. Then connect all the points from 2 to 6 likewise with point K and u ing point K as center, describe from all the points of intersection the curves from line K to 1 as shown. Make the distance from 1′ to 1″ equal to the circumference that the section A has at line 1 to 7; connect 1′ and K with line 1 to K; divide the space between 1′ and 1″ by twice the number of equal spaces as are contained in semi-circle 1 to 7; connect these spaces by lines as shown in the drawing and where these lines cut or intersect the curves as drawn before, it is claimed that the line, which is miter line for section A, is located. This problem as solved may do well enough where it is not necessary that work must come just right or where one need not be over-particular how the work looks when finished. But in case this problem as solved is applied to pipes of large diameter, as in some jobs of ventilating pipes, the discrepancy of just how much it lacks from being correct will become most glaringly apparent. The reason why the solution as given in Fig. 154 is not correct, is explained in the following: As has been shown before in these articles, it is a well-known fact in geometry that a cylinder which is cut by a plane at any other than at a right-angle to its central axis, describes in outline where so cut an ellipse or elliptical curve. This is the case for both the large as well as the small cylinder, as shown in Fig. 154. Now, in order for the section A to form a perfect junction with both the bottom as well as the top elliptical shape as presented by those parts, it must as a consequence also be elliptical at both of its ends. This it is not as developed by the method shown by Fig. 154, but instead, presents a shape elliptical to some extent, but having a greater distance across on lines that are drawn at right angles to the center line 1 to 7 as points 2 and 3 would show, than at lines if drawn from edge to edge at points 5 and 6 and also at right-angles to line 1 to 7. Thus the perimeter or outline as presented by the shape as developed would be in the form of an irregular oval instead of the true elliptical curve that it should have to form a perfect junction with the cylinders as demanded by their outlines on lines1 to 7 and 8 to 9.

In order to develop the correct shape for this part, the following method is to be used: Draw the correct outline of the side elevation of this part. For the plan of both the top and bottom ends draw the correct outlines as presented by the elliptical curves of the ends of the two cylinders. Then use the system of triangulation as shown for the shapes of this kind

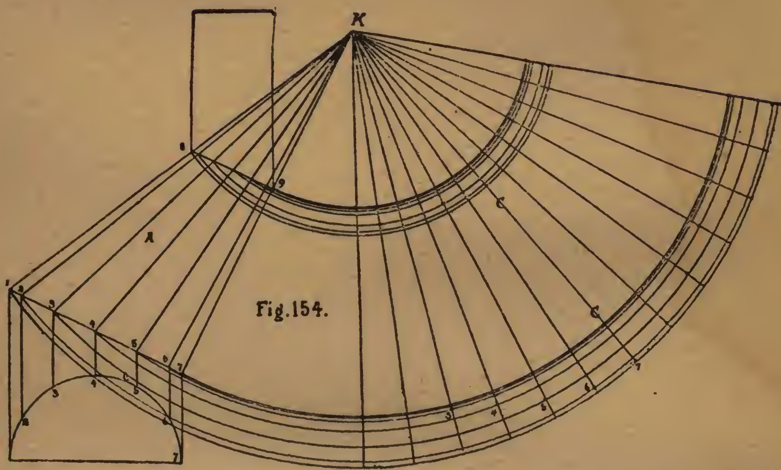


Fig.154.

in preceding chapters. This would be the only correct method to use if an absolutely correct pattern of shape A of Fig. 154 is desired, for it cannot be obtained in any other way.

In the drawings as presented by the Figs. 155, 156 and 157 is shown

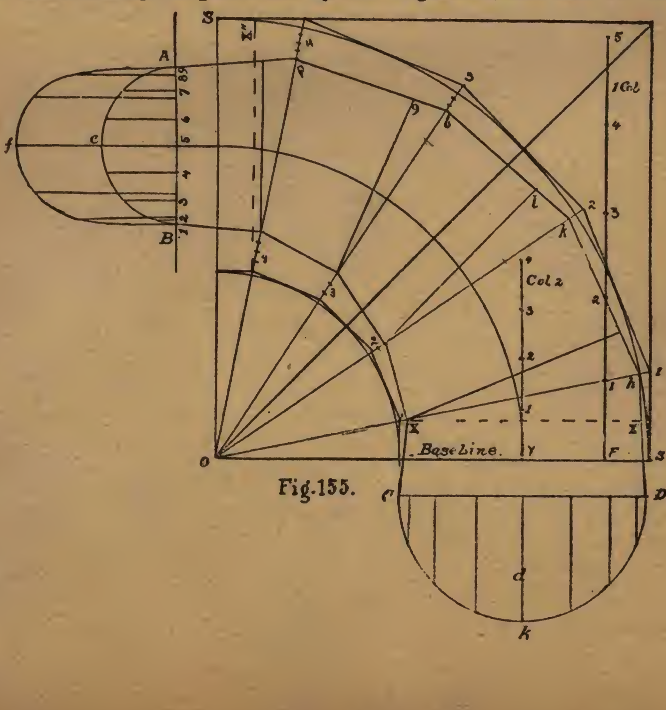


Fig.155.

a complete exposition of the development of a complete elevation of a tapering elbow at any diameter at either end, then how the different sections appear in an out-line elevation on a frustum of a cone and a complete pattern for the entire sections developed by the method used to obtain the envelope of a cone. Although this is not the strict geometrical method to obtain the desired result, it answers well enough in most cases. I will also show the points of difference between the two systems to their full extent, so that the student can use either one, as he chooses. It often happens that the first mentioned method saves time, especially on the smaller work where it is not so particular that every joint is so precise as in larger work of this class. By this it will be seen that it is often advisable that a short method be used to attain a certain end if the same serves the purpose almost equally as well as a more elaborate and consequently longer method would. The most difficult part of obtaining the right proportions of an elbow of this class is in the first steps, when drawing the elevations. In the following description is given one of the best methods by which the desired elevation of any tapering elbow can be obtained and developed up to the stage at which it is necessary that it should be, in order that all the following data can be deducted therefrom. The first step is to draw a side elevation of an elbow as described; this is done in the following manner: I will assume that an elbow required is as the elevation shown by A B C and D of Fig. 155 demands. Draw the right-angle O as center to S S. Describe in the square the outlines of an ordinary elbow of the same number of sections as it is intended the tapering elbow should have. The Fig. 155 shows a five-pieced elbow. Now the idea is that the taper of all the sections of the elbow wanted is to be graduated so that it is a gradual one from the first or starting section, to the end or smallest section of the elbow. The method to accomplish this end is shown on the miter line of each section. On the first division line it is shown by part one, on the second line by two parts, the third line by three parts and last the fourth line by four parts, or the entire difference between the smallest end of the taper elbow and its large end. Each miter line has one part less than the part below it, commencing from the bottom or large end up. The same manner of dividing the space on the outer curve is followed on the inner curve. All this in plainly shown in the drawings. After the points where the outline for the taper elbow cuts the miter lines of the various sections has been established, connect these points by lines as shown and the outline as described for a symmetrical and well-designed tapering elbow is obtained. This leaves the end sections only half as long as the inner sections are at their inner curve. In order to give to these sections a more gradual taper, if it is so desired, the extra lengths as shown between the

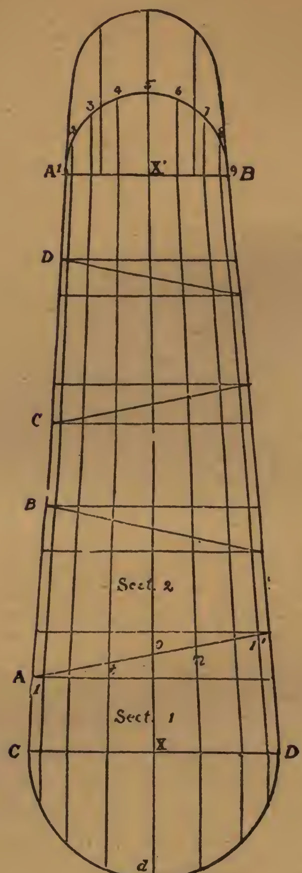


Fig. 156.

ines C D and O S may be added and the connecting outlines of the large section may be drawn from point C to 1′ for the inner curve and from D to 1′ for the outer curve. The same addition may be made to the smaller end.

The steps shown for this problem so far give only the method to develop the outline of elevation for this style elbow. The student has the choice to either use a method of triangulation, such as has been described in these articles, or, if he so chooses, he can use the method described in the following to attain a solution of this problem. Draw the semi-circle C K D; divide it into any number of equal parts as desirable. In this case it has been so divided into eight equal parts. Do the same at the small end

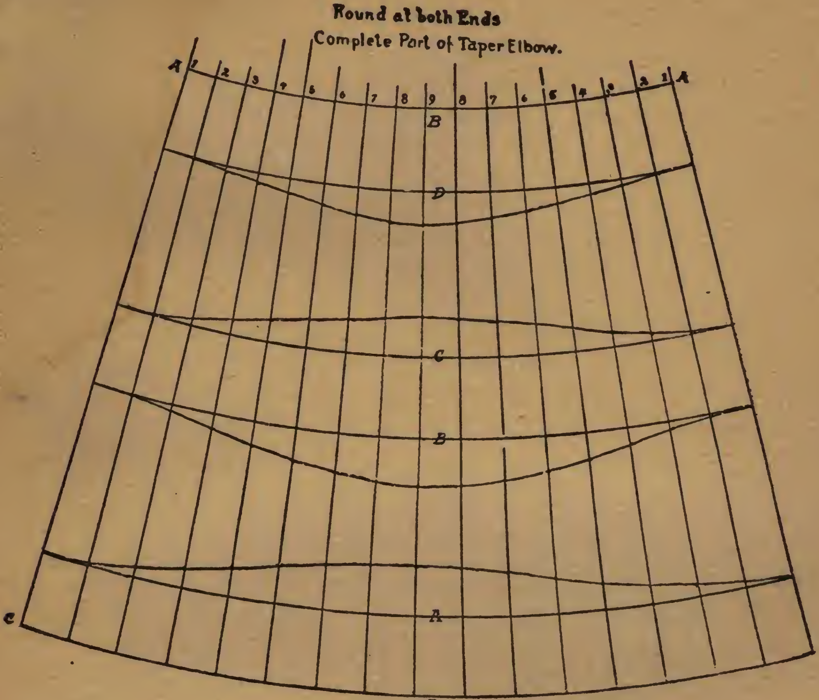


Fig. 157.

The next step in the course of this operation is to determine the height or length of the frustum of the cone as shown in Fig. 156. As the solution of this problem is nothing more or less than the correct division of a cone by the miter lines as demanded, so that when the sections which such division of the cone produces are reversed and so placed together they form the complete elbow as demanded by the elevation, Fig. 155, the first necessary item that must be known is the real height of this cone, so that from it the data for the stretch-out can be obtained for all the sections needed to complete the envelope of each. The manner in which the height of the cone is obtained is as follows: First take the length of each as shown from A B and C and by the numerals 1 to 7. In this figure is also shown the small end of the elbow in shape of an oval. This form is only shown in connection with the regular tapering elbow to illustrate how the same elevation and general method can be used to develop that style of elbow, only with the difference that the shape of the envelope for an oval elbow must conform to the required measurement as demanded for it.

line shown on the inner curve of the elbow as from O to X or 1, from 1 to 2, etc., up to 4 to B; this added together will give the length as shown by column 1 from point F to point 5 shown in Fig. 155. Then on column 1 add the distances that the pitch of the miter line has, from points H to R for the first miter line X to 1; do the same for the three remaining spaces or distances as from points K to L, I to G and P to Y. All these distances it will be seen have been added together on column 2, from point Y to 4. Now add the entire length of all the distances on both columns together. This gives the length of the center line of the cone, Fig. 156, from point X to X′. The outlines as from B to D and A to C are to correspond to the diameters of the large as well as the small end of the tapering elbow and are so shown in this figure. Now draw the miter lines in their correct relative positions from each other on the elevation of Fig. 156, as deducted from the Fig. 155. Also draw the two semi-circles as shown; divide these into as many equal parts as demanded by the elevation and connect the same from their points of inter-section on the lines A to B and C to D with each other, by lines as shown. The next step is to draw the envelope of the cone Fig. 156. This is shown drawn out in Fig. 157. The envelope has been divided into twice the number of parts that the elevation of the frustum of the cone, Fig. 156, has been, as shown by the numerals 1 to 9 on the stretch-out of Fig. 157. Each distance on the Fig. 156 has been transposed to the stretch-out for that section, showing the full development of each miter line in this elbow in full. The sections when developed as described may be cut out and formed to shape as demanded, so that when all the sections are joined together a complete taper elbow, both ends being at right-angles to each other, is the result. In the foregoing easy method the different sections are to fit to each other by thus reversing the sections as cut out of the stretch-out. This is shown in Fig. 156 by the sections 1 and 2. The point 1 of the section remaining stationary, point 1′ of section 2, is turned around so that it comes to where point 1 of section 1 is located, thus causing the elbow, when all the rest of the sections are similarly turned, to finally assume the shape desired. As a matter of course, the sections developed by these methods all have the same angle for their miter lines and it is also true that the miter line which cuts, say between section 1 and 2, causes both these sections to have the same circumferance or length of outline, but it does not leave them in the same shape relatively that they had before they had been so cut. It is a well known fact in geometry that the outline of a cone which is cut by a plane at any angle other than at right-angles to its axis shows the outline so cut to be in the form of an irregular or egg-shaped oval and not, as is often erronously assumed, in the shape of a perfect ellipse. The

absolute correctness of this statement can very easily be verified by the student by his taking a few measurements of the cone under discussion. Take the miter line A to I′ at the point O or the center where the greatest diameter of the cone occurs on a plane at right-angles to its axis, and which is also the only place where two points have the same relative position to each other on a plane oblique to the axis of the cone.

Now the distance through the cone at point N is less than at point t, and this by reason that the point N or points n n are located higher up where the cone is smaller than it is at the location of points t t, although both the points n and t are an equal distance away from the center O and all in one plan. This as a consequence proves that the outline of the plan, as cut by the miter line, does not show in the shape of a regular ellipse, but in the form of an irregular oval. This difference of shape, especially on small work and more so on an elbow which is developed by this method, which having only say three sections makes it more difficult to put the same together, than if made out of four or more sections. The more sections an elbow is made of by this method the more perfectly the pieces will come together, and, as a consequence, the better they will fit. In a four or five-pieced elbow, the difference is not so great but that the pieces can easily be formed so that a good joint can be effected. But where absolute correctness is desired, I would advise that the sections be laid out by systems of triangulation, as shown before; this will enable the student to perfectly match the sections together, so that they fit correctly as they should do in the best class of work.

In Fig. 158 is shown a combination elbow, or an elbow with two outlets from one pipe, both being at an angle from each other, or in other words, the Fig. 158 shows a two way Y, the combined area of both outlets being the same as the area of the inlet. This problem is often met with in furnace work where it is desirable that two smaller pipes be supplied by a larger one, as two 9″ pipes leading from a 12″ or from a 13″ one. The neatest and simplest way to attain the desired combination of these pipes is by making the two smaller pieces in the shape of tapering pipes, so that the large end of each is as the largest pipe, the smaller pipes, when tilted as shown in the drawing, to be of the size required. Then the two smaller pipes are cut so that they miter together as the line A to B shows and both miter to the large pipe, as the line C B to D shows. The operation of solving this problem is as follows: Draw the correct outlines of both the smaller as well as the large pipe, all in their correct relation to each other as desired and presented in the drawing, Fig. 158. Next draw the center line H to K; draw line F G at right-angles to the same. Draw the semi-circle F K G, also the smaller one at the other end. Divide both

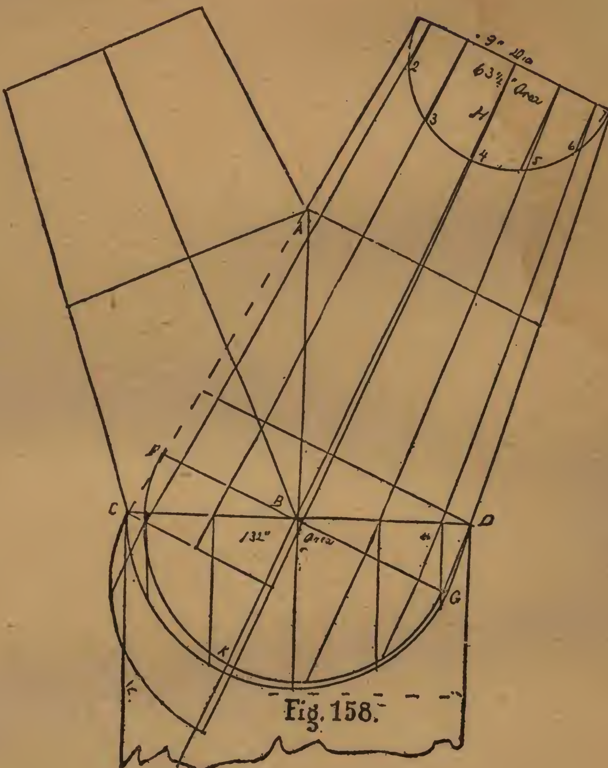


Fig. 158.

semi-circles into equal parts as shown in the drawing by six parts; connect these to the lines from the large semi-circle, which are at right-angles to line F to G, as shown by lines 1 to 7. This completes the necessary preliminary drawing for the data for these parts. The next step is to lay out the stretch-out for each one of the tapering pieces that join together and also to the large cylindrical part, which part needs no particular description, being only a simple cylinder of the diameter as given and of the length desired. The first operation in order is to lay out the envelope of a frustum of a cone as shown. Draw the outline of one of the desired tapering parts, a duplicate of the one shown in Fig. 158. This has been done in Fig. 159. Next divide the entire envelope in twice the number of equal parts that the elevation is divided into. The miter lines in the elevation are shown by the solid lines. Next transpose the distances on the solid lines in the elevation to their respective corresponding dotted lines of the stretch-out. This has been done for all the lines in this problem. The

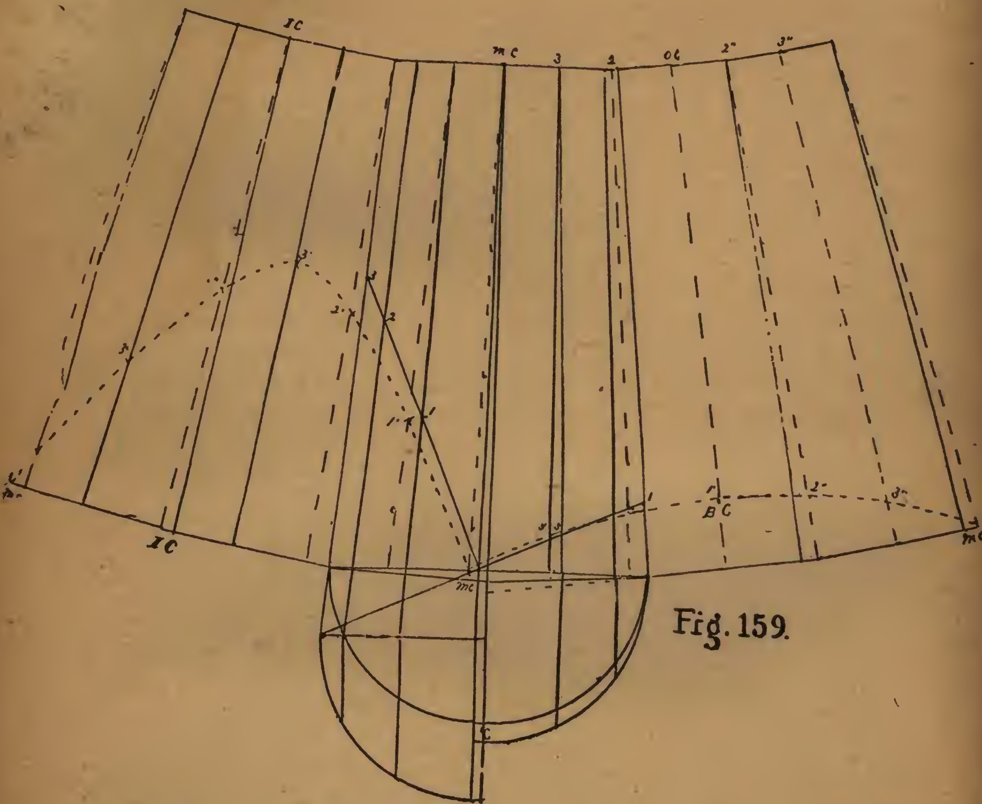


Fig. 159.

point 3 corresponds with 3′ of the stretch-out; 2 with 2′ and 2″ and so on to point M C. The same with line 1 of the back center line to 1′ B C of the stretch-out. After all the distances have been transposed as demanded, draw a free-hand line through the points as established and the miter line for the entire envelope of one part is complete. Make a duplicate for the other part from the part just developed. This done, form the two parts together and fit them to the cylinder or large part. All locks and whatever way these parts are to be joined together, are to be allowed for before the templates are cut out. I may suggest to the student that the neatest manner of joining these parts together would be to double-seam them together. First join the two tapering parts and then connect them to the large pipe or cylindrical part, as the Fig. 158 shows them.

In Fig. 160 is presented a different style of joining two small outlets to a larger inlet. This figure shows how two tapering elbows of a smaller

diameter at the outlets miter to a larger pipe and is a somewhat more difficult problem than presented by the Fig. 158. In this problem the method to lay out the side elevation of a tapering elbow is made use of as shown in the drawing. It is not necessary that both sides be fully drawn out as shown. One side is sufficient for the purpose, as it fully covers all the essential points needed to fully develop the patterns involved in this instance. The two Figs. 161, a plan view, and 162, an end view, give all the data for a complete exposition of every detail as it appears from either point of view. The first step to take in solving this problem is to draw a correct side elevation as in Fig. 160. The method used for Fig. 155 is the one used in this case to develop the correct outline of all the tapering sections of the two outlets, the only difference being that all the measurements are suited to meet the requirements that this problem presents. The entire line A to B of Fig. 160 shows where the two tapering parts

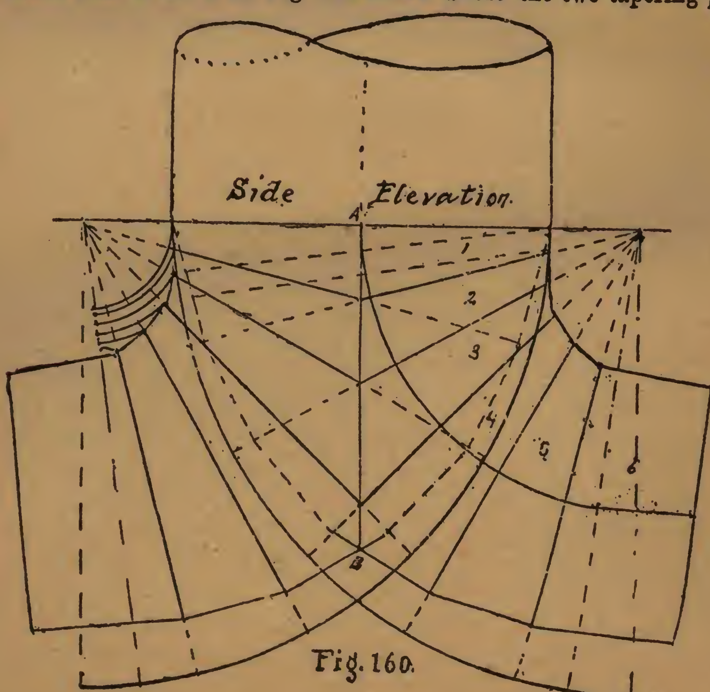


Fig. 160.

join together. The same line of junction is shown correspondingly in the two figures, 161 by line A to B, and in 162 by curve A B to C.

The entire line A to B of Fig. 160 shows where the two tapering parts

join together. The same line of junction is shown correspondingly in the two figures, 161 by line A to B. and in 162 by curve A B to C. In this

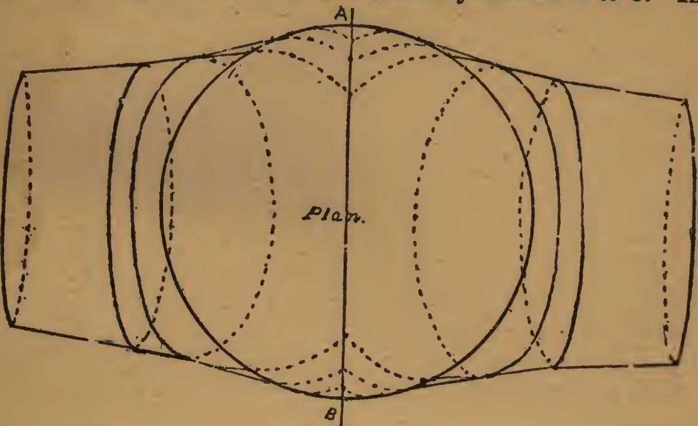


Fig. 161.

problem the two tapering outlets, each, if so set up, would appear in the shape of a frustum of a cone as the Fig. 163 shows, and the envelope or stretch-out of all the parts can be developed by this method if so desired in this case. The method to develop the figure of this cone is precisely similar to that used for the cone, Fig. 156. Use the method for this case, Fig. 163, for all the data needed as to the semi-circles, the division lines, etc. Mark off the ends of each section as shown in this figure, deducted from Fig. 160. This has been done as the drawing indicates, each section being numbered as demanded for the position it is to be fit into. This completes the data required, if it is intended that the two tapering parts are to be developed by the use of the method used to develop a cone. Fig. 164 gives the envelope of the cone developed full size; all the required parts and pieces needed for one side of the tapering outlets are shown fully drawn out. This method, and the way the pieces must be cut out, is not exactly what would be considered the most material-saving way to do this problem, but it is the easiest, quickest, and most time-saving method that could be adopted to attain the end aimed at. A more tedious and at the same time somewhat longer method to develop the various sections is to lay out each section separately by a system of triangulation. Fig. 165 shows the elevation of section 2 and the two semi-circles for the same to be used to obtain the data, if it is desired to lay out the tapering parts by triangulation. I may add that by the last mentioned method, the material required for the envelopes of the various sections can be cut to a little better advantage than by the cone method, and is somewhat more precise in some

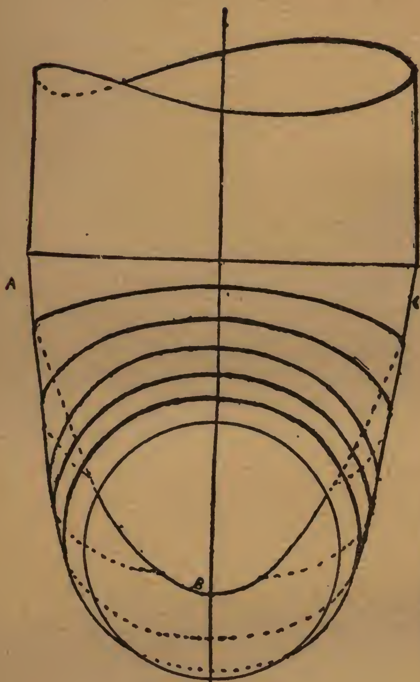


Fig. 162.

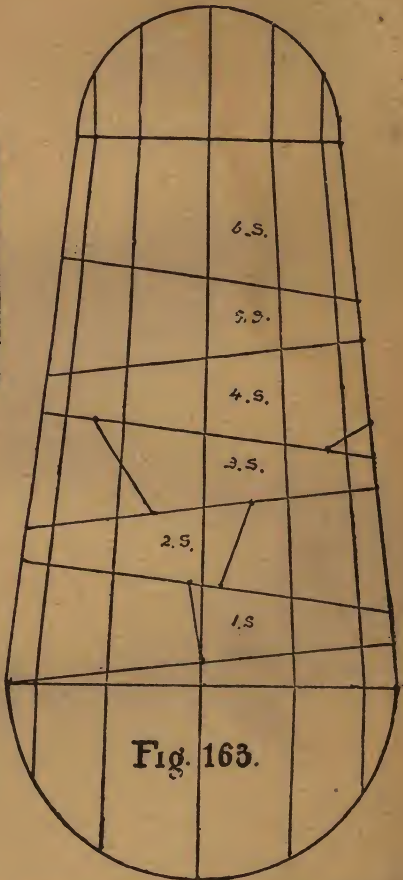


Fig. 163.

particulars than the other method, but all these advantages are far overbalanced by the greater amount of time it requires to develop the problem by the method of triangulation, than it does by the cone method as shown in Fig. 164. Both methods have been fully stated; the student may use whichever he prefers.

One point to be borne in mind is that when laying out the envelopes for the various sections, to allow enough material for the seams or whatever method the workman intends to fasten all the parts together by. A good plan is to double-seam every joint, if the three-way elbow is to be made of tin; if of iron the seams may be lapped and riveted together.

In Fig. 166 is shown the side elevation of an elbow, round at one end and square at the other. One-half of the plan of each end is shown in the same drawing. The elevation gives the full development of a 90° elbow: if

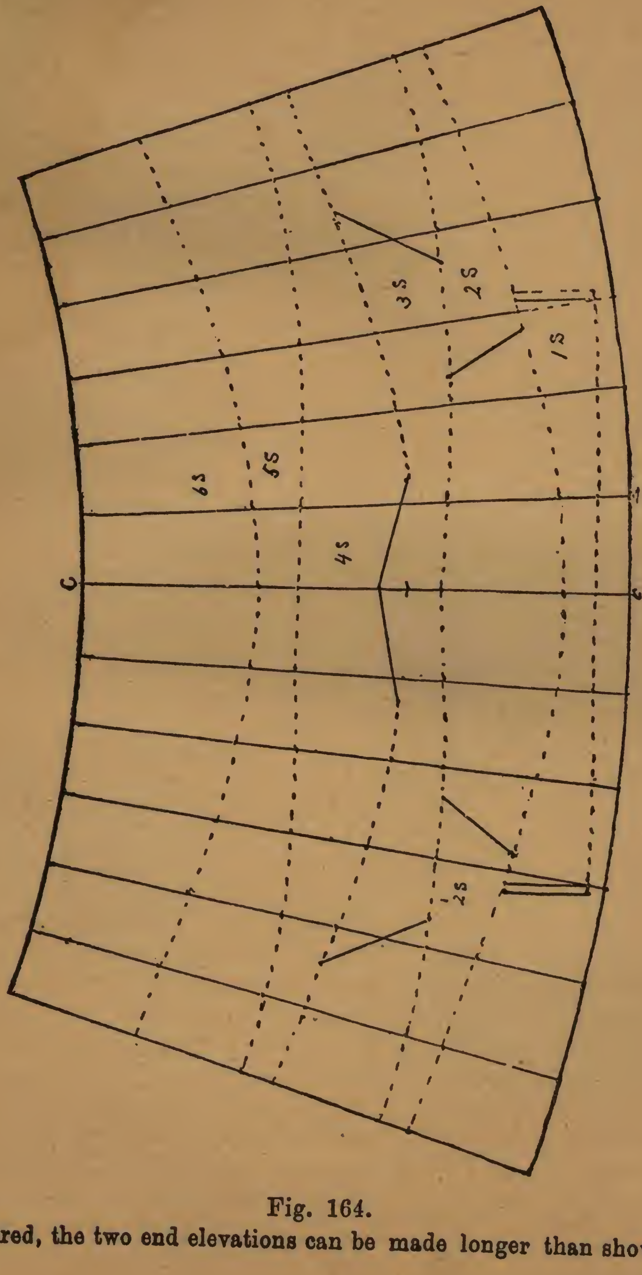


Fig. 164.

so desired, the two end elevations can be made longer than shown in the

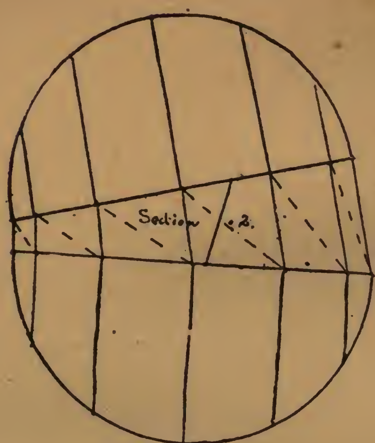


Fig. 165

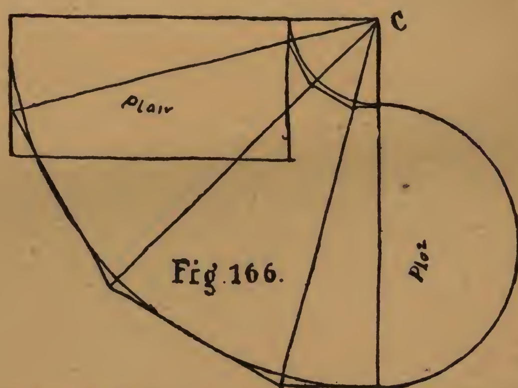


Fig. 166.

drawings, as suits the student. If this is done allowance must be made in the steps further on as required to meet the changed conditions which such a step would cause in the following development of this problem. In this case I will use the data that the present elevation gives. In this problem the same method as used for a cone may also be made use of to develop Fig. 167, which shows the various sections of the elbow, one placed upon the other, in the reverse position from those they show in the elevation Fig 166, or in other words, the finished elbow. After this view as the Fig. 167 presents is drawn, draw the semi-circle as shown, or the plan of that end. Divide the semi-circle into any number of equal parts; in this case it has been divided into eight parts. Connect the line A to B with lines from these points as shown and from these points of intersection connect the line A to B with the corner points of the square end. The correct position of the

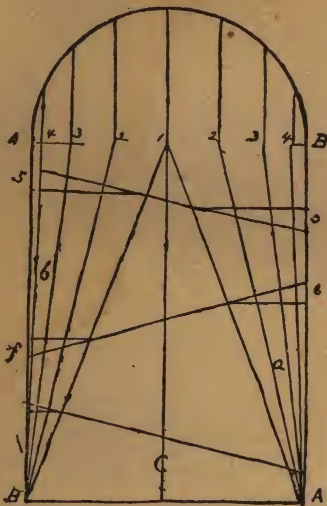


Fig. 167.

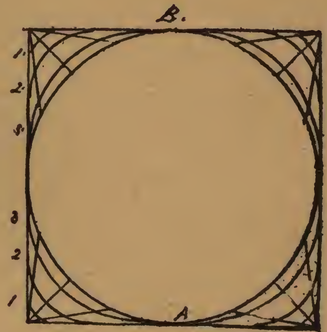


Fig. 168.

miter lines of all the sections are now to be drawn in this elevation as demanded by the conditions that the elevation Fig. 166 requires. Now if the elevation, Fig. 167, is cut into parts at the lines 1 to 1′, 2 to 2′ and 3 to 3′ and these parts are each reversed, it will be noticed that the rounding parts have to be somewhat bent or altered so as to correspond one with another where they meet together. As the bend at 1 will be turned so that it is to join where the bend 1′ is and as the bend 1′ has a somewhat larger radius it is evident that these two bends must be formed so that they will fit together, one made a little larger, the other smaller. This is but a trifling matter in all the junctions in this problem. Fig. 168 shows all the lines that connect from the round part to the square, and the amount of curve each section has at the corners where the miter lines cut through the elevation; the corresponding curve of the opposite side is also shown placed relatively in the plan, for each miter joint as it occurs after the sections are turned as the curve of the finished elbow demands.

The Fig. 169 shows the entire elbow laid out on one stretch-out.

The entire envelope is laid out by the well-known method of developing the envelope of a shape square at one end and round at the other. This has been done for this figure. The two sets of lines a, a and b, b of Fig. 169 correspond to those of Fig. 167 as shown by a and b in that figure. The miter line 1, 1′ of Fig. 167 is shown by the line 1, 1′, 1′ and 1 fully developed in Fig. 169. The same is also shown for the two other miter lines 2 and 3. Each distance for all the curves has been taken from the

points A and B of Fig. 167 and correspondingly transposed to lines of the Figure 169 as shown. After all the distances on the various lines have been transposed to the stretch-out, draw the miter lines as shown and the pattern for the elbow as Fig. 166 calls for is complete. Allow for all locks and seams. This s'yle elbow is sometimes used to connect a round pipe

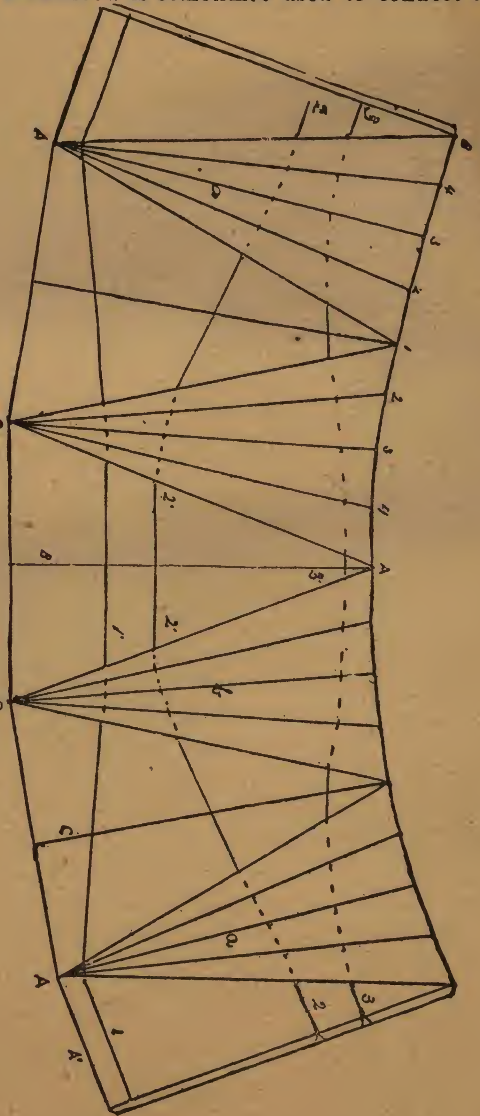


Fig. 169

direct with a floor register, that is, the square end of the elbow serves as a register box. In first floors this style comes handy where it is possible to get the elbow near the floor. This gives the pipe the greatest amount of rise that it possibly could be accommodated with by any style of box made and at the same time have a good unobstructed flow of air to the register.

In Fig. 170 are shown the elevations of four styles of elbows. All are round at one end, but two styles are oval, while the others are square or rectangular at the other ends. Then, also, one of each kind has a different turn from the other as is fully shown by the plan views of both kinds in the

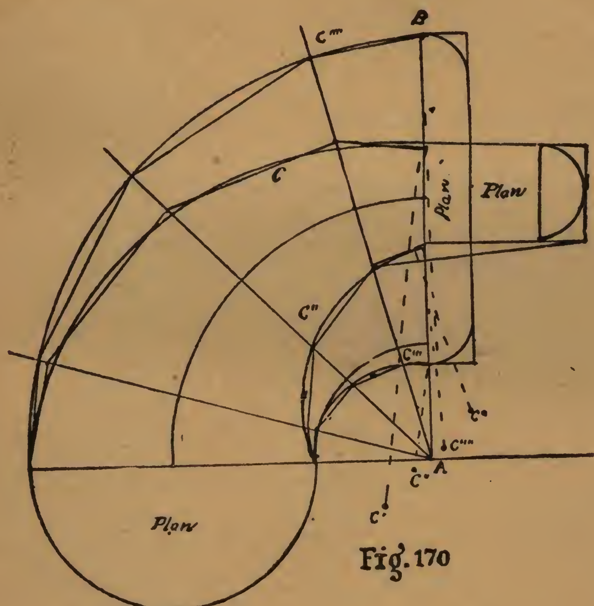


Fig. 170

drawings, Fig. 170. The entire lot are also 90° or square turn elbows, as is shown by the base lines A to B and C. The manner of obtaining correct outlines for the various elevations is the same in some respects as used for Fig. 155, modified of course to suit the problems involved in this case. The outlines can also be developed by using a certain radius and describing a curve for each outline as is shown in the Figure 3 C′ for curve C′. Then C″ for curve C″, etc., up to curve C″ ″.

In Fig. 171 is shown a front elevation of all the four styles and also a side elevation of the envelope of the styles which have their outlets vertically from the base line of the round parts. This envelope A shows all the miter lines for the different parts deducted and drawn out as the Fig. 170

demands for these styles. B of Fig. 171 shows the envelope for the two styles, one rectangular and the other with oval ends on those that have their outlets horizontally with the base line of the round parts of the same. B is the rectangular and C the oval-ended envelope. The plan part of B shows all the connecting lines from the top to bottom for the rectangular outlet, while C shows those for the oval part of the same style of elbow.

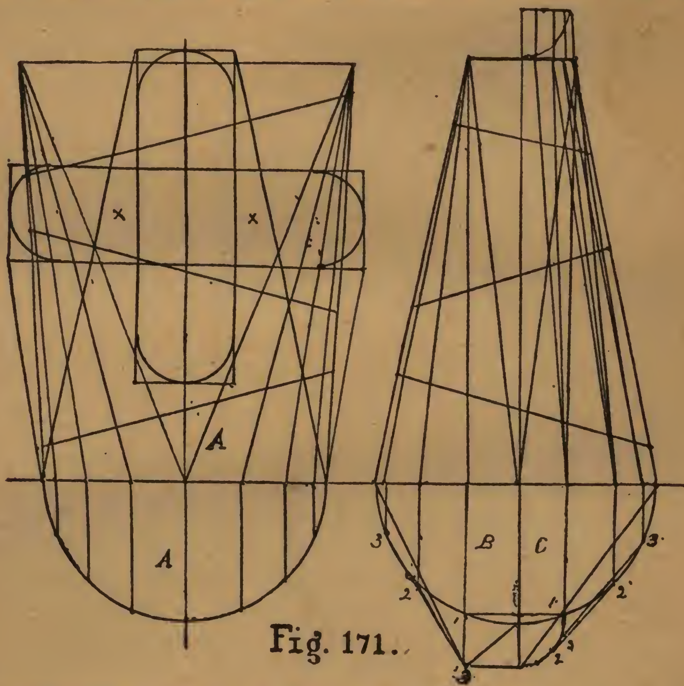


Fig. 171.

The rectangular vertical as well as the horizontal rectangular outlet elbow is laid out by the same method so far as the envelope for each is concerned; the only difference between the two styles in this particular is that they differ in length as to their height when the elbow is finished and also that the miter lines lie in different directions from each other in the two styles. I will first show how to lay out the square or rectangular styles. In Fig. 172 is shown a quarter elevation and plan of each style. Now as both envelopes have the same shape before they are divided into sections, one set of angles will do for either or both. In the figure are shown two styles, but they are merely drawn to show how either style appears if either style is drawn out alone independently of the other. After the plan and elevation as in Fig. 172 are drawn, divide the quarter circle

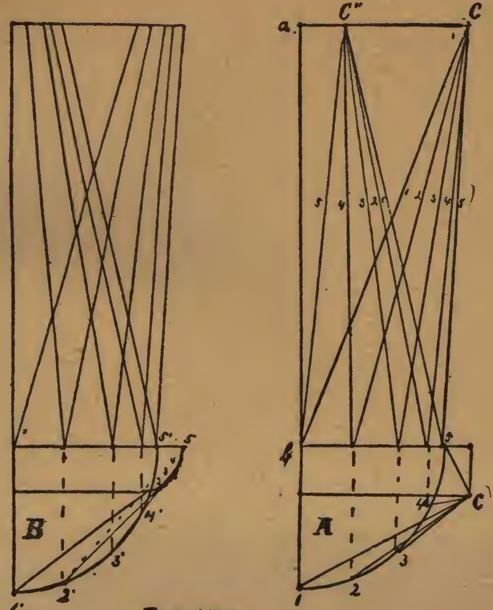


Fig. 172.

into any number of parts as desirable. In this case I have divided it into four equal parts as shown; then connect the point C with these points as C to 1, 2 to 5. The lines drawn from point C' and C'' merely show the relative positions that lines from either point to the points on the circle have when the envelope is formed up, but in this instance they do not show their

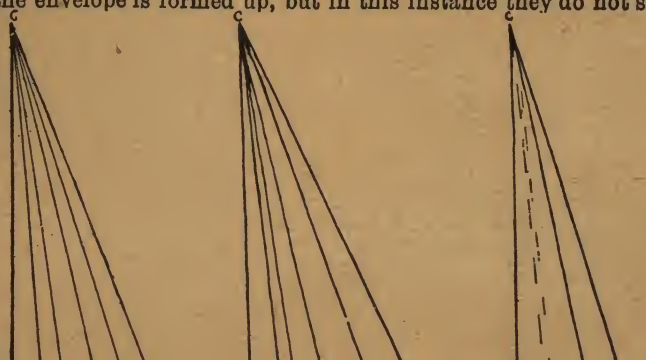


Fig. 173

true lengths in that position, but merely their apparent lengths from this point of view. In order to obtain their true lengths erect the right angle a c a d, Fig. 173 A. Make a to c equal in height as the elevation a to b of A of Fig. 172 is, then make a to d of Fig. 173 equal in length to the distance from point 1 to C of A of Fig. 172. Mark off on line a to d of A of Fig. 172 all the distances from point C to the points 2, 3, 4 and 5 of A of Fig. 172 and connect these points as found by lines to the point C of A of Fig. 173 as the drawing fully shows and the lengths of the lines so drawn are the true lengths of the lines of A of Fig. 172. The foregoing gives all the data needed to lay out the entire envelope for both styles of elbows that have rectangular outlets in this case.

First take the center line of Fig. 174; make this as the height of the elevation of the envelope demands, which is the same as the distance from a to c of A of Fig 173, then lay off on either side one-half of the widest side of the rectangular outlet of either envelope. This establishes the points C, C; using these points as centers lay off the lengths of the lines c to 1, 2, 3, 4 to 5 as done on Fig. 174, the ends of each line to be apart from the next equal to the distance that they are apart on the curve of the circle in A of Fig. 172 and the lines to be equal in length as they are shown in A of Fig. 173 and numbered correspondingly as in both Fig. 173 and the stretch-out of Fig. 174. Next step off the distance from C′ to D equal to the width of the narrow end of the rectangular outlet. Then use D as

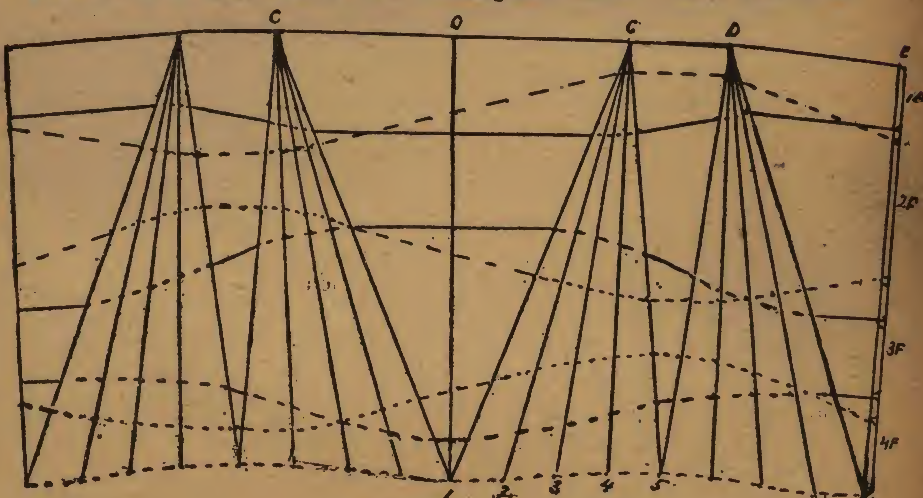


Fig. 174.

center and duplicate the lines as shown in the drawing, also the half of the widest side of the rectangle. Repeat the same on the other side of the

center line 1 to 0 as has been done for side 0, C′ and D, E and the entire outline of the complete envelope for either shape is drawn out. The next step is to develop the miter lines for these two styles of elbows. The part B, c of Fig. 171 gives all the data of the elbow which has the outlet as shown by x in A of the same figure. All these lines are shown fully drawn out by the solid and partly dotted lines of Fig. 174 and are there designated each by an x-mark. The miter lines for the elbow which has its rectangular outlet as shown by the letter R in A of Fig. 171, are shown in Fig. 174 by the dotted lines and are shown in elevation in Fig. 171 by the elevation A′. The transposition of these various distances has been shown in many of the former problems in these articles; for this reason I did not deem it necessary to repeat them again in this instance. This completes all that is needed for the solution of these two problems of the elbows that are round at one end and rectangular at the other, turned either way. The stretch-out can now be cut out as desired and the various pieces of either elbow shaped and put together. Allow for all locks or seams. It is understood that for convenience sake I have used one envelope for both elbows; each elbow as a matter of course must have its own stretch-out. The other problems of the elbows with oval ends or outlets and round inlets may now be taken in hand and developed. Fig. 171, part A, shows the outlets for both styles; all the other data described as to the miter lines is the same for these elbows as for the rectangular style and answers all requirements for these kinds as well. The difference in laying out the envelopes for the oval-ended elbows from the rectangular kinds is that the former require two sets of triangles to accomplish this purpose. These are shown by sets B and C of Fig. 173 fully drawn out to their true and correct lengths.

The plan part B of Fig. 172 gives the positions and lengths for the base lines of angles as sets B and C of Fig. 173 have. The manner of obtaining the true development has been shown by numerous examples before, and also the consequent development of figures of this kind and character as the Fig. 175 shows the full development of one quarter of an envelope as required for this case. Line C of this figure is the center line for an envelope either for a vertical or a horizontal oval outlet such as these elbows require to comply with the elevations as demanded by the part A of Fig. 171. After the full envelope has been drawn out, make a correct elevation of the two views as these envelopes show, before they are cut up into sections; then draw the up and down lines as demanded by B of Fig. 172, suited to whatever style elbow is desired. B of Fig. 172 shows one-half of both styles drawn as called for in this case. After the complete elevation of the style wanted is drawn out as directed, draw the miter lines on this elevation as shown in part A or B C of Fig. 171 as the case may be for this

Fig. 175.

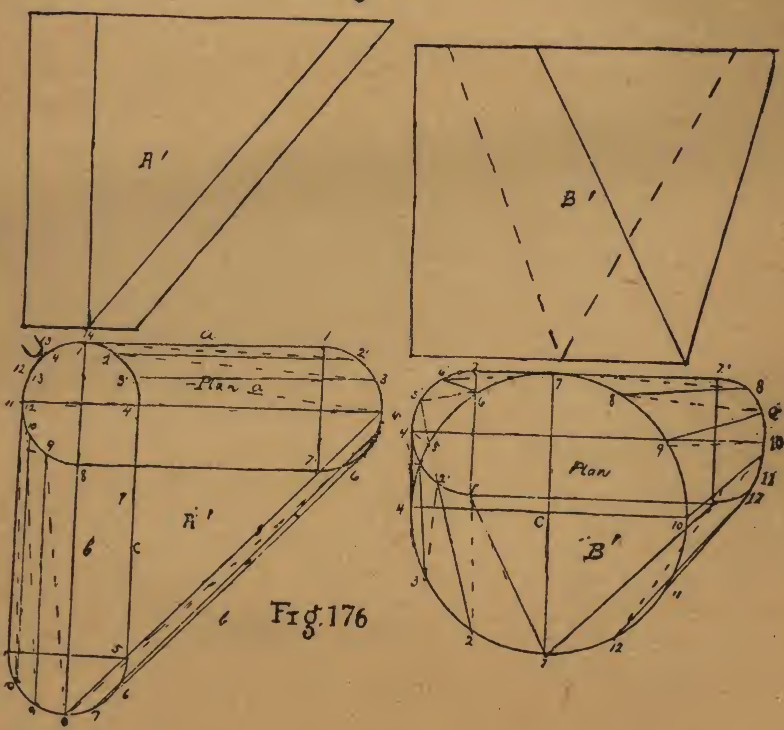


Fig. 176

elbow under consideration. When this operation is done, the entire data is obtained from this last drawn elevation for the miter lines on the stretch-out as Fig. 175 shows one quarter of. This done, the complete pattern is obtained for an elbow with an oval outlet turned in the direction to which the pattern has been laid out for, the other end of the same being round.

Fig. 176 shows two styles of turns or, for the want of a more appropriate designation to meet just such cases as these shapes are, I will also term them elbows. It is sometimes the case that a turn, as A of Fig. 176 shows, is wanted. A shows the plan view and A′ an elevation of the same. As will be seen. the two ends of A are both oval, but turned at right-angles to each other, as shown in the plan view A. The part B shows a somewhat similar shape only that it is round at one end and oval at the other. B′ is an elevation of this plan. The method of developing the envelopes for both these figures is by triangulation. The method used being the same for both problems I will only describe one, namely, the problem A of this figure. The two ends, as shown drawn in their relative positions to each other, the first step is to divide the circumference of each into equal parts; this has been done, for each, into 14 parts. The point 14 of oval a and point 1 of oval b are directly over each other, as are also the points 13, 12 and 11 of oval a over the points 14, 13 and 12 of oval b. Ths first step to take now is to connect the various points by two sets of lines in order to ascertain the correct length and position of the angles needed for this problem. In this case I will make one set of the angles of

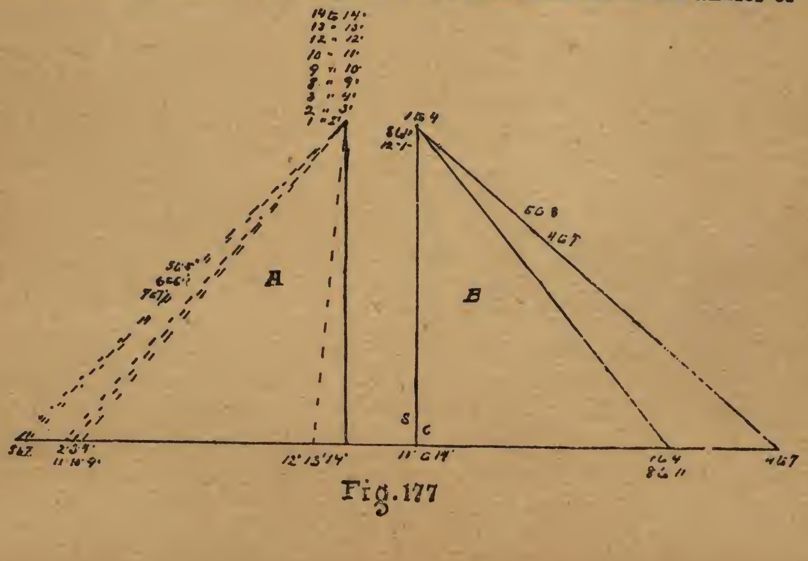


Fig. 177

solid lines while the others are dotted lines only. Commencing with point 1 of b, connect it with point 1′ of a, etc., up to 4 of b to 4′ of a, as shown in Fig. 176. These lines are shown in Fig. 177 by set A by line 1 to 4 to the point 1′ to 4. The length or height of line S S is equal to S S of the elevation A′ of Fig. 176, and the distance from C to point 1′ to 4′ of A of Fig. 177 is equal to the distance of the plan lines from points 1 to 4 from plan b to the points 1′ to 4′ of plan a of Fig. 176. Then the points 5 to 8 of b are connected to the points 4′ to 7′ of a and also points 8 to 12 and 12 to 1 of b to the points 8′ to 11′ and 11′ to 14′ respectively to points 8′ to 11′ and 11 to 14 of plan a. This completes the solid lines for this problem. All the foregoing lines are shown in their true length in A of Fig. 177. A similar operation has been done for the dotted lines. For these points the connection is made from point 1 in plan b to point 2′ of a, etc.; that is, the points in plan b all connect to points in plan a which are one unit higher, as 7 to 8′, or 12 to 13′, etc. All the connections and the true length for each dotted line is shown in B of Fig. 177 for this problem, as deduced from the plans A of Fig. 176.

The next step is to lay out the envelope or stretch-out for this figure. This is shown in Fig. 178. Commence at either end. In this case I have

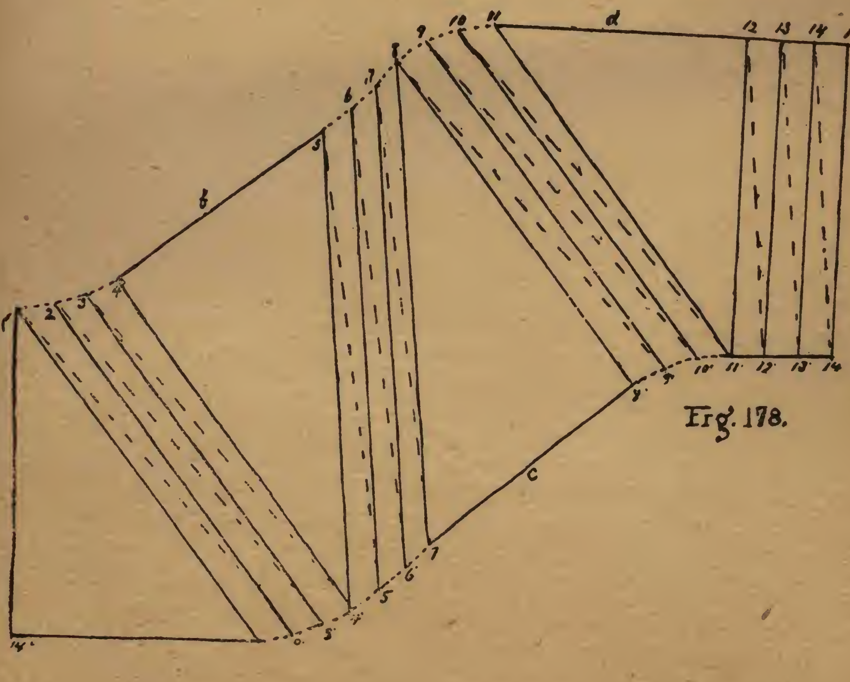


Fig. 178.

done so at line 1 to 14; this line is of the same length or height that the elevation is at that point and is so shown on line s s of A in Fig. 177. At

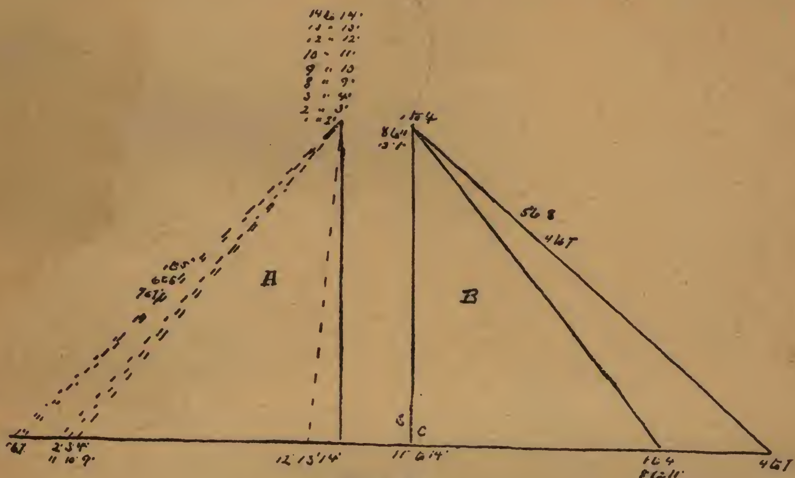


Fig. 177

a distance equal to the length between points 1 and 14 of plan b and between points 1 and 14 and between points 14′ and 13′ of plan a of Fig. 176 draw the line 14 to 13′ in Fig. 178. The dotted line from point 14′ to 14 is to be of the same length as is shown for the same to have in B of Fig. 177. The four lines as 1 to 14′, 14 to 13′, 13 to 12′ and 12 to 11′ are all parallel each to the other and of the same length and in one straight line or position from each other in Fig. 178. This is by reason of the position that the two plans b and a have relatively to each other in Fig. 176, thus placing them all in one plane horizontally and all equi-distant from each other in the line of the curve of the ends of both plans, as is shown in Fig. 176. Now from point 11′ to 11 of plan b of Fig. 176 is equal to the distance from point 12 to 11, as line d of Fig. 178, and is so shown in the stretch-out. Make line 11′ to point 11 equal in length to the length as shown for the same in A of Fig. 177. Then from point 11′ erect the dotted line to point 10 the length demanded for the same in B of Fig. 177. The distance from point 11 to 10 is to be equal to the distance on the curve of plan b, Fig. 176, between the points 11 and 10 of that curve. A similar method is used to develop all the remaining lines of the stretch-out for this problem. As each line and set of lines is so plainly shown and the operation of drawing them out in the figure is almost the same in each instance I do not consider it necessary to give any further description of them

for this case. When all the sets of lines are drawn out as the Fig. 178 shows, allow for all locks and seams, then cut out the pattern and form it to shape as demanded by the plans and elevations of Fig. 176. This completes this problem. The problem shown in B of Fig. 176 is of the same general character and is developed by precisely the same steps, etc., as the problem A of the same figure. As a consequence the student has only to refer to the description of the methods used for the shape A to apply them for the solution of the problem as presented by B of the same figure. Both these shapes are often made use of where turns and changes in the shape of pipes occur in furnace work. The same method used in the solving these problems can also be applied to almost any shape met with in furnace pipe work. I would urge the student to thoroughly master these problems and the application and use of this system of triangulation by which the problems have been solved in these cases.

Fig. 179 shows the side and end elevations of standard square pipe angles and elbows. A shows two angles, B a full square elbow and C shows a square bend the flat way of the pipe. These styles are made in all sizes

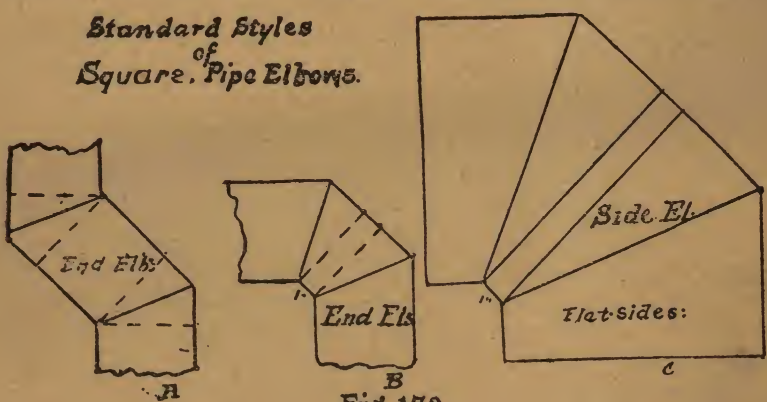


Fig. 179.

of pipes in furnace work and are mostly made at 45° and 90° angles. Fig. 180 shows an example of some of the difficult and awkward shapes that the furnace man is often called on to make in pipe work. The figure has only been added to this article to make it the more complete by comparison and to show for what kind of work it is practicable to give rules, diagrams and methods so that the student can work after them, as has been done for all the preceding shapes and forms up to Fig. 179. But for this shape, Fig. 180, or, for that matter, for any special style or kind of bend of this class, I would deem it useless to draw out patterns. In the first place, a problem

as presented by this figure is all simple lines and angles; these, if the data is put down in such a shape that the workman can readily read it, require nothing more than a fair amount of attention and a willingness to use a certain amount of common sense when, say for instance, the workman is called upon to get out a shape as would be required by the front A, right side elevation B and the plan view C of Fig. 180. These views are so easily read that any amount of written or printed description could not render them any plainer or more easily understood. It is, as a matter of course, understood that to lay out the envelope for this figure requires some ability and a certain amount of constructive ingenuity, so that the workman can form some conception of how the shape of the article will appear when done, as the drawing Fig. 180 demands.

In this respect some workmen show decidedly more talent, quickness in seeing a point, etc., than others. But the student can become a first-class workman in these branches by close study and regular and correct practice. I would suggest that when problems as shown by Fig. 180 are to be solved to draw out all the views (as plan, elevation, etc.), as minutely and precisely as possible. If this is done the student will find that it becomes a comparatively easy matter to solve the correct outline that each part of an envelope has as a shape shown in Fig. 180.

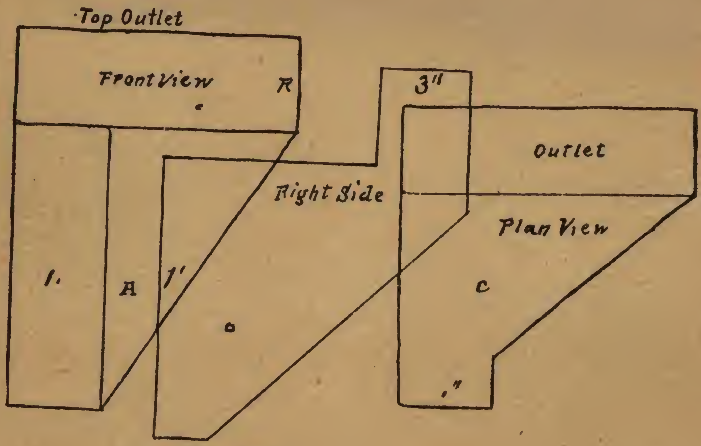


Fig. 180.

In this article I have given every form, shape and kind of elbow known in the furnace trade; all the patterns are applicable to either light or heavy work of all kinds in this branch. Many of the methods used to develop the problems as given can also be applied to other shapes than for

those that they have been applied to develop them; particularly is this the case with the system of triangulation shown in the various problems developed by it. In conclusion I will describe a few very interesting facts and points regarding the degrees that elbows and their patterns have. In the first place the methods of determining the angle that the rise of a miter line for any elbow has from the base or horizontal is nothing more or less than a simple deduction of the actual angle or central-angle of a given polygon which has four times as many sides as a given elbow which has been laid out and deducted from a quadrant or one quarter of a polygon. Thus the ordinary square or two-piece elbow has a miter line of 45°; four of these elbows put together would make a square or a four-sided polygon, and as each elbow is made of two pieces, it follows as a natural sequence that the miter line must be 45° from the base line, the two ends of the elbow being of 90° to each other. Thus it follows that a four-piece elbow having three whole sides in a quarter turn, a complete turn, or four of these elbows if joined together, would present in outline a complete twelve-sided regular polygon. The statement that a four-piece elbow presents three whole sides only is correct as far as the actual amount of surface that is shown is equal to three sides of a polygon as used for such an elbow, but in fact a four-piece elbow actually shows four sides; that is, it presents two whole sides and one-half of two more sides of the polygon, thus really only showing a surface equivalent to three full sides.

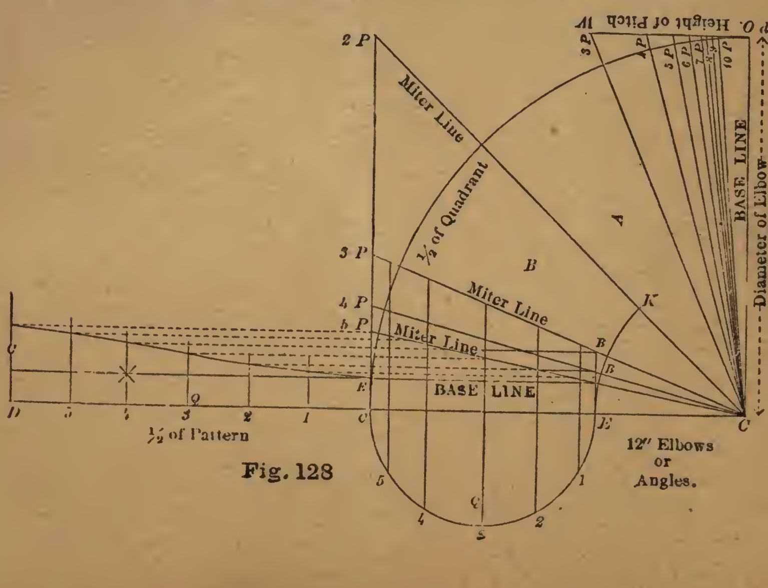


Fig. 128

To still further show this point when laying out an elbow as shown by Fig. 128, the quarter-circle as shown in that figure is divided for a four-piece elbow into six equal parts; then for the two end sections of this elbow is set apart one section for each end, while for the two center sections two of the remaining four pieces or divisions of the quadrant are required for each section of the four-piece elbow, thus making the elbow out of two whole center sections and two half end sections, or as a whole, three whole sections. The foregoing amply shows that four four-piece elbows have the outline of a regular dodecagon or a twelve-sided polygon, and as a consequence the miter lines of all square or 90° four-piece elbows are and must be the same angle as one-half of the central-angle for such a figure. In Fig. 181 is shown a central-angle of a twenty-four-sided polygon by X and a to b. In the upper left-hand section of Fig. 181 is shown the practical application of the foregoing descriptions as to the polygonal angle that the elbows have. The angles there shown are for from a two-pieced elbow,

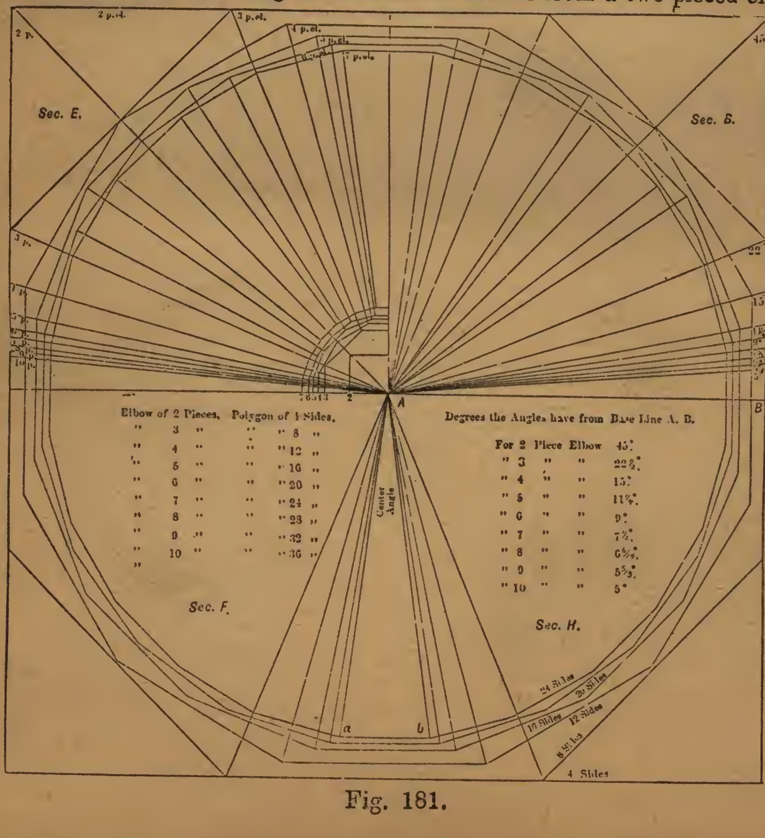


Fig. 181.

or square elbow, to a ten-pieced elbow. Full side elevations of six styles of these elbows are shown, namely, fron a two-pieced to a sever-pieced elbow.

The corresponding polygons for these elbows are also fully drawn out in this figure. The more sided figures I have not shown as the foregoing clearly conveys the point, while if more figures were drawn out in such a small sketch it would only tend to confuse the eye. In this figure the three-pieced elbow is shown to be inscribed or its outline is bounded by an octagon or 8 sided polygon, that of a seven-pieced elbow by a 24-sided one, etc. The figure also gives the number of sides of the polygons from which each kind of elbow from a two piece to a ten-piece elbow is deducted, by the table in section F at the lower left-hand corner of the figure. At the right-hand lower corner is shown by a table the degrees the m ter lines have or at what angle they are from the center p int A to the line A to B or the base line of these angles. The manner in which the degree of an elbow is determined is by dividing the quadrant or 90° by the number of parts that the same is divided into for any elbow of which it is desired to ascertain the number of degrees the miter line has. Thus for a three-piece elbow a quadrant is divided into four parts, thus, $4 \div 90^\circ = 22\frac{1}{2}^\circ$; for a ten-piece elbow the quadrant is divided into 18 parts as shown in Fig. 126; thus $18 \div 90 = 5^\circ$. If the quadrant is divided into a certain number of parts for an elbow, the polygon which is a complement to the elbow has

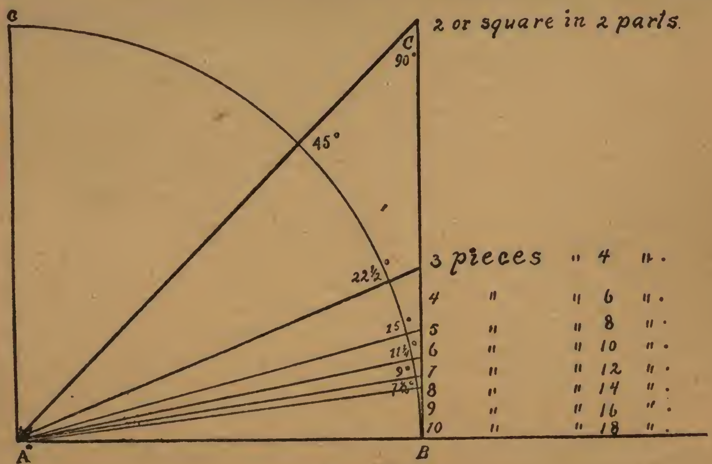


Fig. 126.

just twice as many sides as the quadrant is divided into, and consequently four times as many sides as the elbow has whole sections in its make-up.

This amount being as stated before just half as many whole sections as the quadrant is divided into for each elbow. The object of introducing the foregoing described properties that the figures which elbows form when they are placed together as described, and the other interesting facts in connection with the above, is to enable the student with the aid of the imparted knowledge to make use of a set of angle patterns for the purpose of laying out the various styles of elbows as enumerated.

Fig. 182 shows the angle of an octagon angle pattern used for a three-piece elbow. By making the base line 12″ from A to B, the height or rise at B to C is 5 3-16″. All the angles that this pattern has are fully shown in the figure. Similar patterns can be made for any or all the other angles as desired. Use the method as shown by the quadrant, divided into as

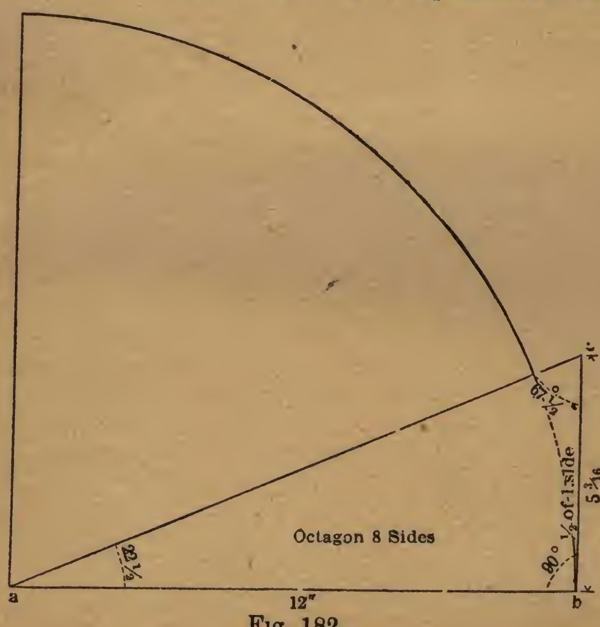


Fig. 182.

many parts as the angle desired. The angle, Fig. 182, that the miter line A to C shows is the same for any sized elbow; that is, for elbows of any diameter, but they must be with their inlet and outlet at right-angles to each other or square, and made of three sections or pieces.

XVIII.

CHIMNEYS

Proper and adequate smoke pipe connections, sufficient sectional chimney area, together with sufficient draught to meet the full demands for the proper working of a furnace, are paramount and vital conditions which must be provided for to insure successful operation. If the conditions enumerated in the foregoing are complied with at the beginning when erecting a heating plant, we may reasonably expect to be able to obtain all the benefits of most of the good qualities claimed for such a furnace, as far as the ability of the furnace is concerned to meet these demands, such as producing a quality of warm air which is at once pure and healthful to the persons occupying the rooms to which the furnace is furnishing the heated air. These desirable conditions, aided by the proper and prompt supply of an ample amount of suitable fuel to the fire in the furnace, to produce the heat to warm a sufficient amount of pure cold air which is to pass up to the rooms above when heated, may be obtained only by a strict compliance with conditions as stated before. In the following are given a few reasons why these conditions are ever present, and at all times have to be met if the furnace is to give a full return for the amount of fuel used and also the full satisfaction which the just return for the outlay or cost of the apparatus entitles the purchaser to. In the first place, if the construction of a furnace is correct, if ample allowance is made for the exit of the products of combustion from the furnace itself at its smoke collar, and if every part is made of the best material and of sufficient weight and strength to stand the usage to which it will be subjected in active service, all the joints being in cast-iron furnaces cup shape and cemented, or if for wrought iron or steel plate furnaces riveted tight in a workman-like manner, there will be at no time any danger of the furnace leaking out any gases into the air chamber, particularly any of the deadly carbonic oxide gas (the result of imperfect combustion), providing the chimney has ample draft for the work required. To prove that the chimney must be at fault if a leakage of gas occurs; that is, if the furnace complies with all the conditions mentioned in the foregoing, one need only post himself on the nature and the real operation which is going on inside of the fire box of a furnace durin; the process of combustion, which is that instead of an outward flow of air there is a constant influx of air into the furnace at

every opening offered to the same, and this inflow must be going on all the time or else there cannot be any flame or fire. The only time when an outward flow occurs is when the dampers are all closed, or if opened, the smoke flue is not sufficient to carry away the smoke and gases from the fire in the furnace. This escape of gases, etc., often occurs through the joints of the feed door and also when the feed door is opened, but if the draft in the chimney is in good working order, the flue of ample size and unobstructed, the air will be noticed to be flowing into the furnace and the smoke out of the proper channel only, and not otherwise out through doors, joints, etc. The essentials of perfect combustion being oxygen two parts, carbon one part, and heat enough to raise both to a temperature of about 700°; if these elements are to combine properly the necessary conditions must be present. In order to attain this we must have properly built flues to carry off the residue or smoke and gases from this combination, or, as usually termed, the process of combustion. The question naturally arises: What constitutes, or how is a perfect chimney built? The best form of chimney next to a round or circular shape is the square shaped shaft or flue, perfectly smooth inside. From 64 to 140 sq. in. area through section inside will be large enough for any furnace built. For the shape of the flue compactness of area is the desideratum, instead of being a long and narrow rectangular shape. The reason for this is that in the narrow shapes the current of heated gases in the center part of the flue is checked by the colder or chilled currents at the ends and in the corners, and for this reason such a flue will not give full satisfaction, and in most cases it will be found that this style of flue has a poor draft. In passing up through a flue the currents of hot smoke, gases, etc., assume a spiral motion upward. Therefore, a round-shaped flue would be the best. But a shape of this form will be found perhaps once in a thousand cases, the universal style and shape being the square or rectangular flue. This shape allows the smoke to flow up the center, while the four corners are somewhat colder, and as a consequence the currents in those corners have a more sluggish flow than the more highly heated and consequently more rapid currents which pass up through the center of the flue. If it is possible, never build a chimney in an outside wall, but rather have it located in an inner wall. The chimney being exposed to the chilling influence and action of the cold winds and the exposure of a greater part of the area of their surface to the colder air often causes the chimneys to smoke, while if they were built more centrally in the inner walls of a house this would perhaps not be the case, more of their surface being sheltered and the cause of chilling the entire flue thus being avoided, the gases from the furnace ascend more rapidly and the better the draft of the flue.

In building a chimney nothing but good hard brick should be used. For those portions of the structure built inside of the house use nothing but the

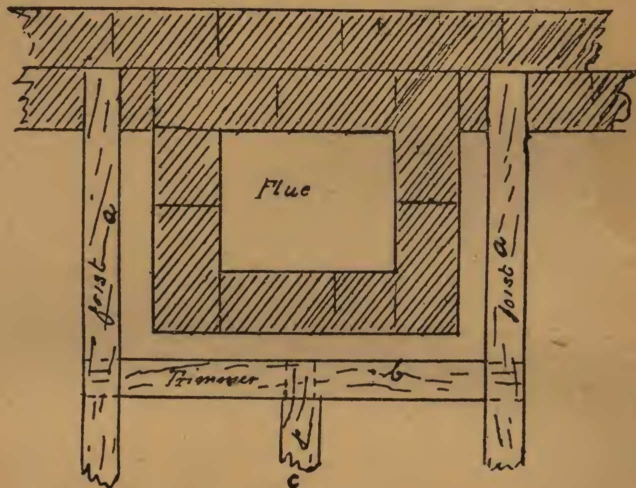


Fig 183.

best mortar, build the chimney from the cellar up and do not hang or let it rest on a bracket built up against the wall; then, if possible, use cement mortar for those portions which are on the outside above the roof. See to it that the entire inside of the flue is smoothly plastered from top to bottom. Do not build a chimney close up to rafters and beams; under no circumstances have any beams or joists set into the chimney wal's—this practice alone of incompetent builders has been the cause of a great many fires and not a few disastrous conflagrations. Fig. 183 gives a good idea how to arrange the wood-work around a chimney flue.

It will be thus seen that the two joists a a have the trimmer b either spiked or, better still, mortised in; then the joist c is mortised to the trimmer in the same manner, thus clearing the flue entirely and avoiding every ordinary risk making the woodwork as safe as every due caution would demand. The thickness of the chimney walls in dwelling houses, and most ordinary houses is 4½″ or half the length of one brick, as shown in Fig. 183. In some buildings the thickness of walls of smoke flues is considerably more, such as in high buildings, churches, schools, etc., the walls having a sectional thickness of from 9″ to 18″, but this latter thickness is met with very rarely. It is almost needless to state in connection with the above that for chimneys of the weight and thickness last named, good

solid foundations are absolutely necessary.

For those parts of a chimney which are supported throughout, stone may under some circumstances be admissable, but brick is always preferable for the purpose. The abutments of a chimney should be tied into the walls by wrought-iron bars of sufficient number and strength, turned up and down at the ends, and built into the jambs for several inches on each side. Where slabs of stone or slate are placed level with a floor before the chimney, they should invariably be laid in sound mortar, cement or other incombustible or non-conducting substance, and it should be at a distance of not less than $4\frac{1}{2}$ inches from the joists, flooring or any other woodwork. A chimney built only up to the roof and stopping at that point is always dangerous. Every chimney in a house should be perfectly distinct and separate from every other chimney, from the hearth to the external opening. Chimneys may safely be built in stacks, but they should on no account have any connection with the stacks. Brickwork around flues should not be less than $4\frac{1}{2}$ inches thick in any part. By the Code Napoleon it was not permitted to build a chimney against the wall of an adoining house without isolating it by an intermediate wall of sufficient thickness to prevent heat passing to the neighboring premises.

The chimney for a furnace should if possible be located as near to the furnace as it can be conveniently arranged. Have the flue built as straight upward as possible, and as high as any part of the building or the buildings adjoining. Every chimney should have flue clean-outs, particularly those flues that are used for the furnace flue should have a clean-out box at the bottom, a foot below the point to where the smoke pipes from the furnace enter the flue. One very desirable point too about a chimney should be that it be easy to get at the flue so that the accumulated soot can be readily cleaned out. Particularly is this true where soft coal is the fuel used for a furnace connected with the flue. In ordinary furnace smoke flues the smoke and waste gases from the furnace have a velocity from 2 ft. per second to as high as 8 to 15 ft. per second, the temperature ranging all the way from 500° at the inlet to 300° at the top or outlet in some cases. Other instances where the flow of gases is not so rapid and therefore a more economical and less wasteful rate, is where the gases enter the chimney at about 250° to 350°, leaving the chimney top at from 150° to 200°. The conditions referred to in the foregoing depend altogether on how the heating apparatus is arranged and designed to further the economical consumption of fuel. This subject will be accorded a more minute treatment further on. I have in the foregoing shown some of the most desirable qualities that a well-built chimney should have, such as to be of ample dimensions well built throughout, and smoothly plastered inside from

top to bottom with first-class mortar, etc. What are really the facts and the conditions that the average furnace man meets in every day actual practice in setting furnaces? Far different from the much-to-be-wished for state of affairs that would be present if the smoke flues for furnaces would average to be anyway near to the mark that they should be. Talk to the average furnace man about a flue lined with circular glazed Scotch drain tile—he would call such tale nonsense. Such a state of affairs, I may venture to say, would hardly come under notice during a life-time but once or twice of one man among a hundred in our trade. They would say that all such fine-spun theoretical conditions are well enough for some dreamer to write about, as such stuff looks well enough in print and does no one any harm. The true conditions which are really met with every day by practical furnace men are, if in old houses, cramped and illy constructed flues, rough and ragged interior surfaces; if some years old the flue is often nothing but a mass of rotten bricks, the flue being full of soot, sometimes there being fully a flour-barrel of soot and ashes to take out before the flue can be used. This is often the case where the flue is used for a stove on an upper floor, the ashes, etc., having never been cleaned out of the bottom of the flue until the unfortunate furnace man wants to use it to connect his furnace to it, and, as a consequence, he is the one on whom it devolves to clean it out. Then, if the building is a new one, almost every flue that has come to my notice had either more or less mortar and brick at the bottom, dropped down into the flue while in course of construction by careless brick-layers. In some cases that I have seen the bottom of flues filled up to the height of from 4 to 5 ft., dried solid and hard, taking a man a whole day to chip and chisel it out. This mass of obstructions the brick-layers should have cleaned out before they left the job when the chimney was first being built. The chimney is the chief and really one of the most important factors on which depends the success of any furnace to fulfill the task of heating a house satisfactorily. The planning and disposition of the flues, location of heater, etc., of a heating plant, are subjects in regard to which nine-tenths of our architects should have a more practical knowledge than they seem to have, judging by the poor discernment displayed in these matters in their plans.

In most cases in the construction of buildings too little attention is bestowed upon the building of proper flues, or upon the manner in which the building is to be heated, that being usually left for decision until the building is nearly ready for occupancy. If it is decided to heat the house with a hot-air furnace the services of the furnace man is then called for.

He usually finds unsurmountable obstacles to contend with, owing to the improper location, size, and construction of the flues, which frequently

have to be reconstructed at considerable expense. If used as they are found, which is frequently done to save expense, or at the instance of an incompetent workman, who will maintain silence on the subject through fear of losing the contract, the result is in nearly every case unsatisfactory, the furnace requiring more frequent attention and more coal than would otherwise be necessary to produce the desired temperature if the flues for the furnace had been made correctly in the first place. In some instances it will happen that there is no flue at all in the building that extends down below the cellar or basement. In such a case the furnace man must do the best he can, if the parties owning the house are not willing to build an extra chimney for the furnace, but are willing if the house is provided with mantels to have one of them closed up and the flue belonging to it utilized for a flue for the furnace. In such a case the furnace man has comparatively an easy problem to solve.

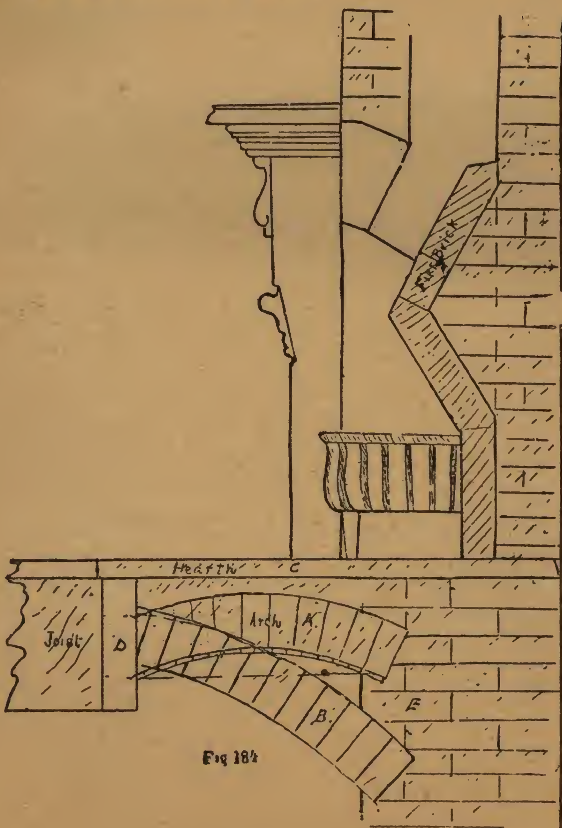


Fig 184

In Fig. 184 is shown a section of a common mantel or fire grate from a side point of view. Two views of A and B show how two styles of the arches are constructed which support the hearth C. These arches are supported at D against the header shown and at their ends they are shoved to the piers E. To arrange a grate as shown for a flue for the furnace the entire fire-place must be torn out and a flue built as shown by Fig. 185 for the side section. This view shows the arches A or B, whichever style had been used for this fire place, entirely torn out and in their stead trunnions substituted. This view also shows the entire front bricked up solid and the smoke flue extended downward below the floor level. The plan view, Fig. 186, shows the disposition of the supports or the tee irons from that point of view and also the shape in which the flue is carried downward below the level of the floor. This is shown to be circular; an 8 in. cylinder about 15 in. long is placed in position and around this the bricks are laid in an upright position. These bricks are well bedded in mortar and every precaution is taken to have the job made fire-proof and secure. Fig. 187 shows the front view of the closed up fire-place. The dotted lines show the course that the smoke flue has up behind the front wall and in the interior of the chimney. The walled up portion shown can be plastered over with a hard coat finish, and then painted or colored to match the mantel.

The interior of the pipe from condensing along with gases and smoke passing through to the chimney. The asbestos wrapping tends to retain the heat in the smoke pipe, thus promoting a constant and even flow of gases throughout the full length of the pipe thus wrapped. Whenever a smoke pipe passes through a wall or wooden partition, provide proper safety thimbles for the purpose, these having at least one inch space between the inner and outer circles. Wire and secure all smoke pipes from furnaces securely and have the end which fits into the chimney smoke collar fit tight and snug. Do not under any considerations have more than one fire to the furnace chimney flue, that being the furnace fire itself. Have the smoke pipe at all times as far away from all wood work as possible. Eighteen inches is the regulation in some cities. Line all exposed parts of wood work first with asbestos paper and then with bright tin lining. This combination of fire-proofing renders the pipes as safe as all due care can make them. Do not let the smoke pipe project too far into the chimney flue and have it so arranged that the pipes can easily be got at to be cleaned out. The chimney is to be provided for in a like manner. This last point must be in order so that the flues can be cleaned out regularly, this being made necessary where soft coal is the fuel used for the furnaces. Clean-outs must be provided for any vertical smoke pipes which are used to convey the smoke from soft coal fires. The nonsensical assertion is made by some furnace firms that the pipes they put up are self-cleaning. These

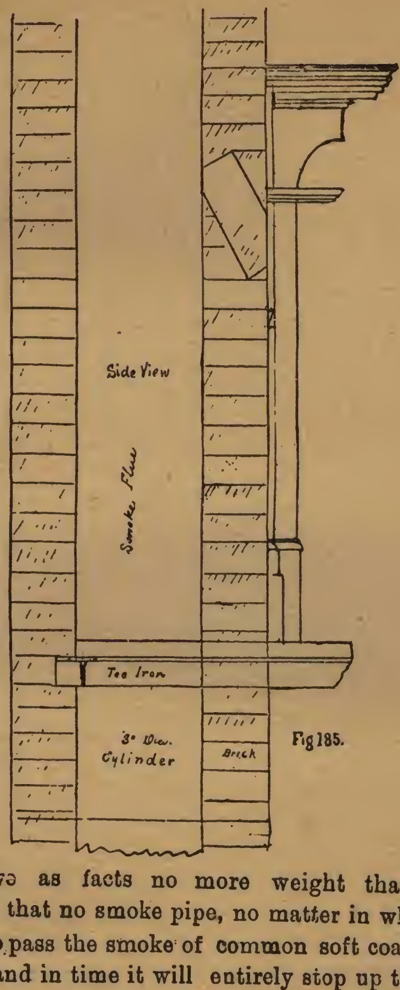


Fig 185.

wild statements have as facts no more weight than that of being uttered. The fact is that no smoke pipe, no matter in what position it is placed, if it be used to pass the smoke of common soft coal through it, the soot will accumulate and in time it will entirely stop up the whole area of the inside of the pipe, hence if not promptly attended to, the necessity for clean-outs. All other pipe holes that may be in a chimney besides the one used for the furnace smoke pipe are to be closed up with tightly-fitted stoppers.

It is as a matter of course understood that all joints between the different sections of pipe are to be perfectly riveted so that they are smoke and gas tight. Fig. 188 shows one of the many styles of smoke pipe connections between a furnace and a chimney.

The foregoing is one of the surest remedies for a case of too much draft in

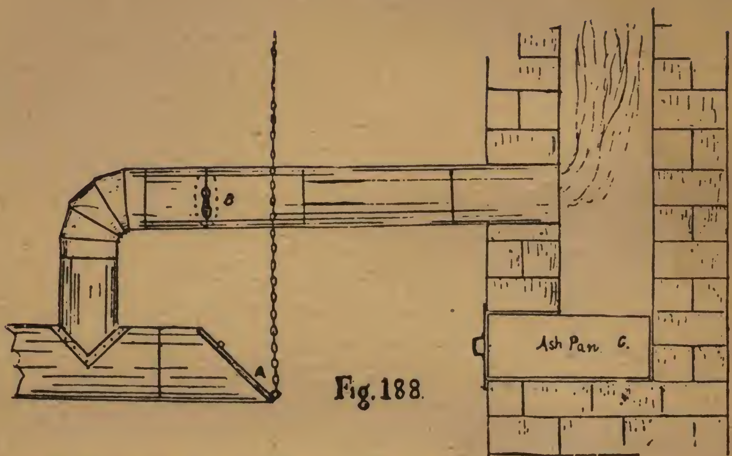


Fig. 188.

a furnace smoke pipe connection. In Fig. 188 at C is also shown the manner in which an ash-pan or clean-out pan is placed in the bottom of a flue of a chimney. A full detailed description of this feature has been given. There are in practical use a good many checks, dampers, both automatic, and others with mechanical movements, draft and temperature regulators, etc., a complete exposition and full descrip ion of which was given in chapter XIV. I will describe still another general method which remains to extract heat and to add to the effective radiating surface of furnaces. It consists in adopting the best shapes and forms for each individual case of the largest amount permissible of smoke outlets or heat radiators inside the casings of furnaces, constructed independently from the main body of the furnace, but connected securely to the body in such a manner that all the heated gases and products of combustion from the furnace must pass through them before leaving the furnace and then be conveyed through the smoke pipe to the chimney. These adjuncts to furnaces greatly add to their heating surfaces and correspondingly increase the power of extracting heat from the hot gases passing through them which otherwise would be dissipated or lost through the chimney flue to the outside air. Fig. 191 shows a more or less modified style of smoke pipe connection from shapes and kinds made use of by a half-dozen leading furnace manufacturing firms. A brief description will suffice to elucidate this figure. The smoke as seen enters at the top end on one side of the pipe, then makes the entire circuit of the radiating pipe-down A through the square part B and up through C to the outlet D. This style is a very effective appliance for the purpose. The two Figs. 192 and 193 show the plan

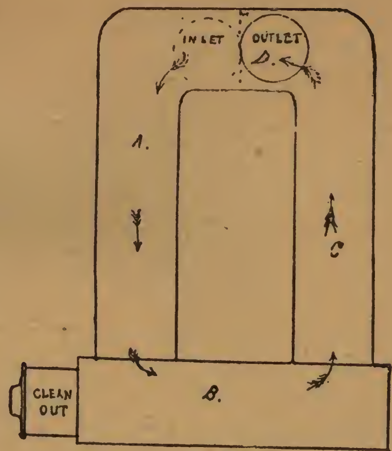


Fig 191.

and a side elevation view of an effective sheet iron radiator or smoke conveyer from the outlet at A of the furnace shown by Fig. 192 and shown correspondingly by In of Fig. 193. The heated smoke, gases, etc., entering the radiator at I of Fig. 193, take the course indicated by arrows, go clear around and exit at the outlet O.

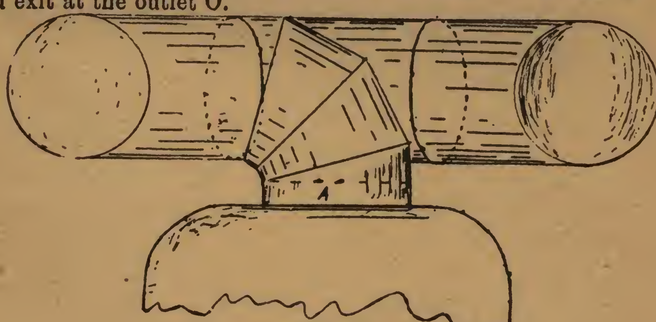


Fig 192.

This figure shows the most direct smoke way that could be devised. If it is desired that the smoke, gases, etc., should have at once a smooth and easy passage-way without too many obstructions, but still arranged in such a manner that the draft and outlet from the furnace be under perfect control as shown by means of the check or regulator A and the damper B in the horizontal pipe itself, the style as described is one of the best that is in practical use for chimneys with a normal draft. For flues that for various causes have more draft than is wanted and which are to be checked in such a manner that the heat from the hot gases and smoke in passing through

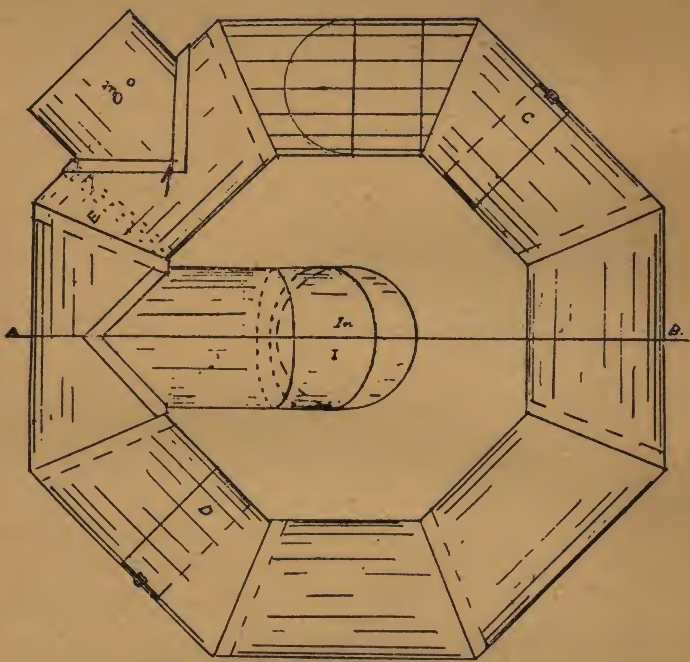


Fig 193

the smoke pipe to the chimney can be saved or utilized to heat the part of the cellar in which the smoke pipe is located, Fig. 189 is given to show a method that was used by a furnace man to overcome this difficulty. In this case the natural draft of the chimney proved too powerful for the furnace to do any heating with it if reasonable economy was to be observed in the operation of the apparatus, Fig. 189 shows the plan view of the remedy adopted in that instance. There were plenty of clean cuts provided for these connections. The job as done worked splendidly and gave entire satisfaction. With some furnaces a large amount of heat necessarily passes up the chimney with the smoke. This not only is wasted but endangers the house by overheated flues. To meet just such cases where a chimney draft is too strong and it is not desirable or convenient to apply any other remedy to check the same an arrangement in the smoke pipe at its entrance at the chimney can be made use of, as shown by Fig. 190. This consists of simply fastening a tapering pipe into a smoke pipe which has a larger diameter

Every inch of surface of this appliance is effective heating surface. I have found it very effective when applied and used with the cheaper grades of natural gas furnaces and also for hard coal furnaces. The radiator shown by the two views is best made of from 20 to 16 gauge iron. All the miter

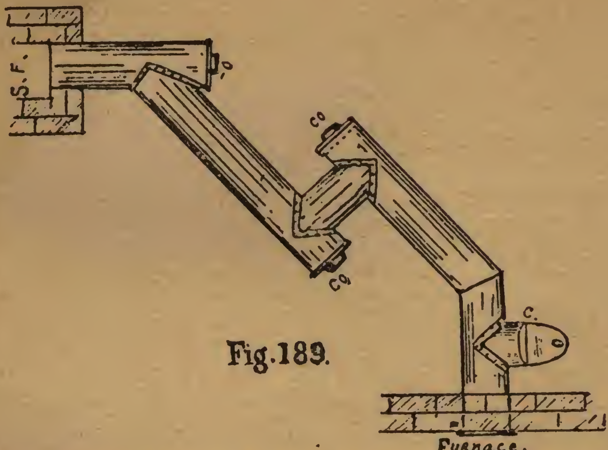


Fig. 189.

joints are to be securely riveted so as to be gas and smoke tight. The two slip-joints C and D show how to make the entire radiator fit together in two sections. At E is shown by the dotted lines where the division plate is placed so that the smoke is diverted into the proper course that it should

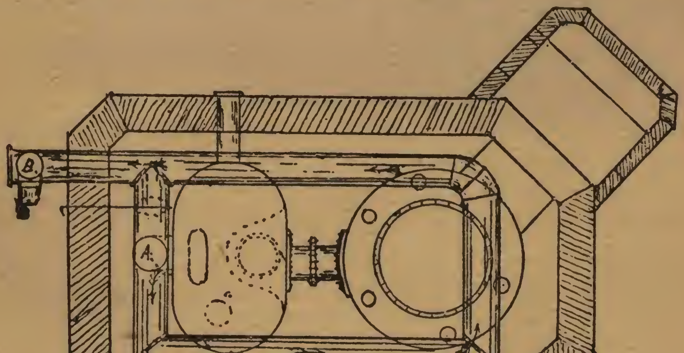


Fig. 194.

take for this radiator. The patterns for the miters are the same as for a three-piece elbow and need not be shown again for this case. When a job of this description is to be done, none but the very best Juniata iron should be used. It is almost needless to state that the mechanical ability of the workman should be of the highest grade to make a successful and perfect piece of work. Figs. 194, 195 and 196, shows by plan, side and end eleva-

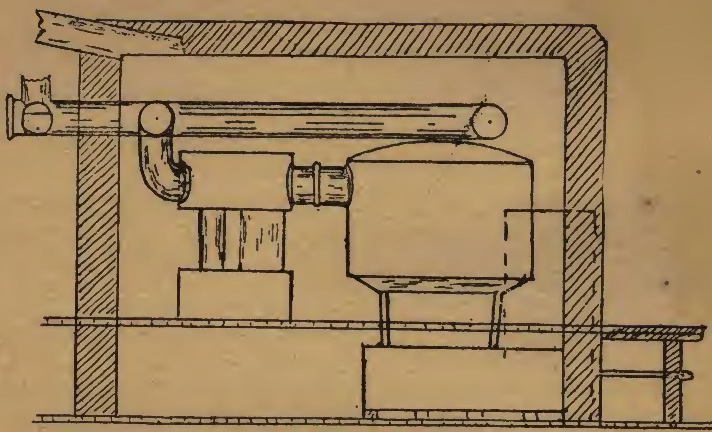


Fig. 195.

tions how a brick-set furnace can often have its heating surfaces increased to a certain extent by arranging the smoke outlet from the furnace somewhat in the style as shown by these figures. Other styles would demand

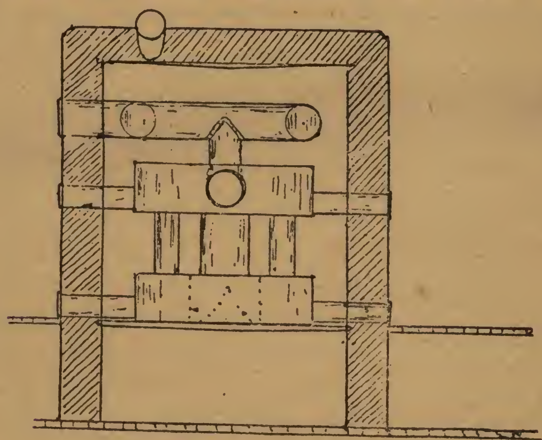


Fig 196.

a modification of the plans as here presented, but the general idea can readily be seen how such an extra radiating surface can easily be added to almost any brick-set furnace.

The plan, Fig. 194, shows how the flow of smoke, gases, etc., are conducted around the circuit and out to the outside of the furnace. It also shows all the clean-outs needed so that at all times the pipes can be readily got at to be cleaned out if necessary. Fig. 195 gives the complete side

view and Fig. 196 the end view. This style of arranging the pipes on the interior gives the most satisfactory results. Next is keeping a smoke pipe connecting a furnace to a chimney flue warm in case the same be of any great length and located in a cold cellar, by wrapping with asbestos paper to prevent the gas passing through the smoke pipe from condensing, resulting in a sluggish and poor draft by reason that the vapor or moisture condenses and the volume of the heated gas inside the pip becomes less and more compact being chilled by the colder air or the outside of the pipes This will occur if the pipes are not protected. But in case none of the conditions mentioned in the foregoing are present as in a case where the smoke-pipe from a furnace passes through a comparatively warm cellar and the chimney has a good draft, the smoke-pipe being of some length, placed or running in such a direction that it, if encased by a larger pipe and this connected at one end with suitable connections to a register placed in the floor of a room directly above the smoke-pipe, the same could be comfortably heated with the heat radiated from the long smoke pipe, if encased and the hot air guided to the register through this and into the room above. How to manage to attain this result, together with all the practical details of the construction of a casing as described, is

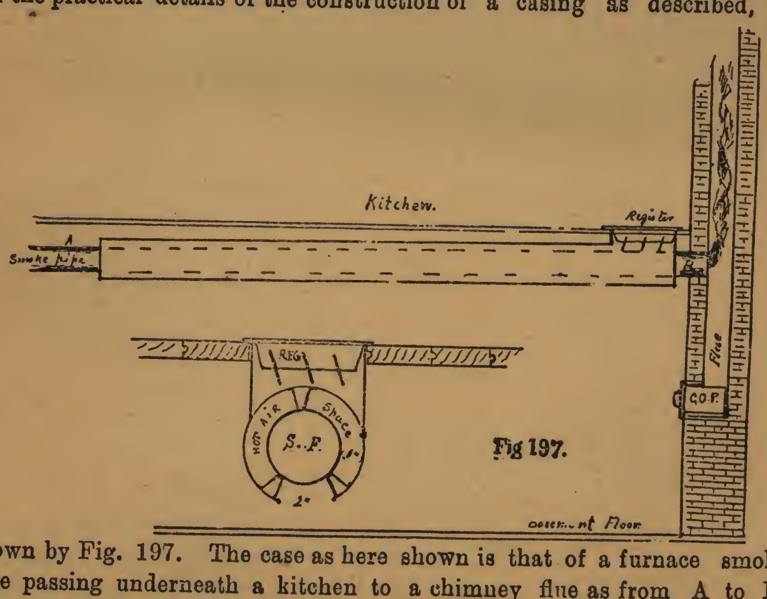


Fig 197.

shown by Fig. 197. The case as here shown is that of a furnace smoke pipe passing underneath a kitchen to a chimney flue as from A to B. This smoke-pipe is shown to be encased almost its entire length, then connected to a register in the floor above and the heat let into the room through this. In this case the air supply is shown to be obtained from the cellar by the casing being open at the bottom about 2″ wide and about

three-quarters of the entire length of the casing. The end nearest to the register or outlet is to be arranged so that no air can be lost through this end, but all of it must pass up through the register whenever this is opened. The plan of taking the fresh or cold air for this case out of the cellar may be permitted if the cellar or basement is kept clean and free from the ashes, dust, etc. Otherwise it would be advisable to put a tight casing around the smoke-pipe and have this connected with a fresh-air inlet from outside the building. This latter method would be the preferable plan in any case, but such jobs as the first-described method are put into houses in more instances than the last described better, more healthful and cleaner method. Another plan of heating rooms by utilizing the furnace smoke-pipe for the purpose that has come to my notice in some instances is to pass the smoke-pipe up through the floors, rooms, etc., to the second, or as in some cases even to the attic space, before it enters the chimney flue. For those who care to have a job of this kind done in this style the utility of the method is all that may be desired, but so far as looks and appearance go it does not rank very high in the opinion of the writer.

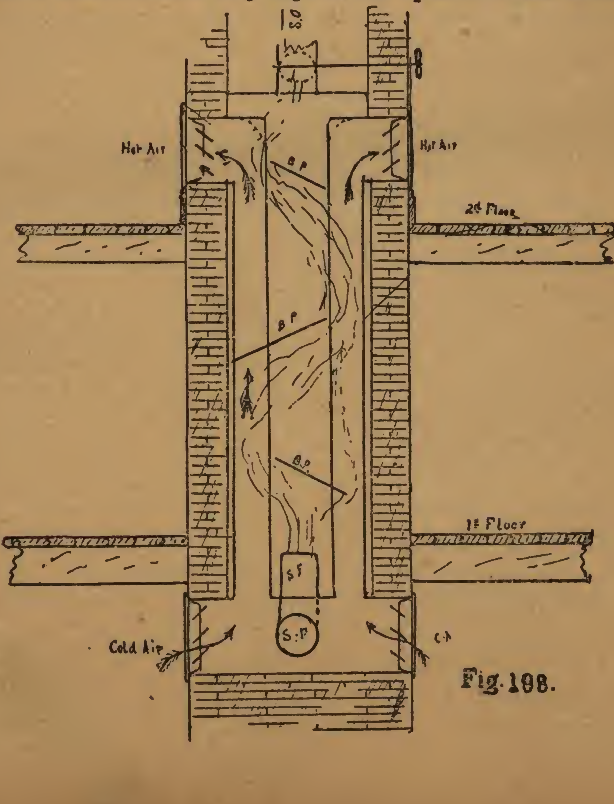


Fig. 198.

By Fig. 198 a method is shown to arrange a smoke-flue so that it is possible to heat one or two rooms on an upper floor if they immediately adjoin the chimney flue wherein the contrivance is placed to accomplish this end. It often occurs in old houses that were built at a time when the only prevailing idea of a comfortable heating system was to heat houses with the large open fire-places, with correspondingly large flues for the same. I may venture to say that the time when these notions were the most prevalent could not have been such a long time ago, judging by the numerous examples of this style of house that furnace-men come across. Generally these old buildings are large, roomy affairs and to heat every room with as economic a method and as little outlay as possible the furnace-man must take advantage of every device that he can command; especially is this the case where he must come within some fixed price to provide for efficient apparatus for the heating of a house. Fig. 198 shows how a case occurred to a furnace-man where it was desired to heat two rooms on an upper floor, but there being no chance to run wall-pipes to the floor above, the figure shows how the desired result was accomplished by using a chimney-flue and connecting two separate pipes, one to each room, around both of which the hot gases and smoke of a furnace passed while ascending through the chimney flue. The smoke inlet was at S F; then turned upward the smoke passed back and forth from side to side of the smoke-flue as shown in the figure, baffle plates, as shown in the flue, being so placed as to cause the smoke to impinge on the surface of the warm-air flues. At the upper end above the warm-air flues a plate was placed with a collar attached to it provided with a damper to check the draft of the chimney when deemed necessary. The chimney had a very strong draft and no check was used for the furnace below at night-time, but only the damper as shown in Fig. 198. This answered all purposes required for this case. By Fig. 199 is shown a method to check a furnace smoke-pipe and also to ventilate the cold or foul air from collar into the smoke pipe. The damper A is shown connected with a chain or cord over pulleys so that the check or damper can be regulated from the rooms above. The arrows shown at the bottom of the pipe indicate the course that the cold or foul air takes into the ventilating pipe attached to the furnace. In Fig. 200 is shown a ventilating inlet with an upward turn in the smoke flue of a chimney. This style is about the only kind that is admissable for the purpose, providing that a suitable check be placed in the vent so that no back-draft and flow of gas or smoke can occur in the room into which the vent is placed. The manner in which the vent operates and how it is caused to perform the work it does is as follows: The cold air in the vent becomes heated by the hot gases flowing upward in the chimney-flue; this causes a like upward motion of the air in the ventilating outlet from the room into

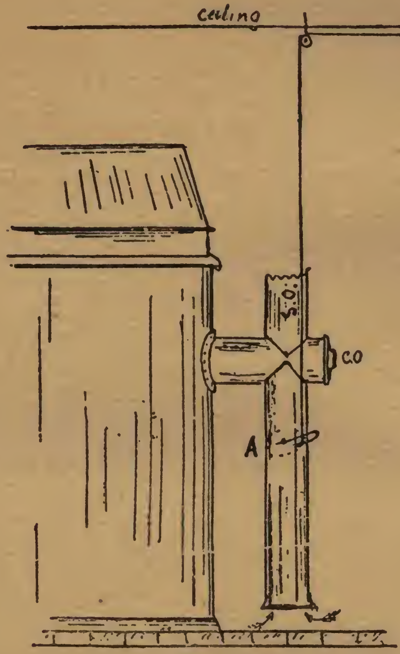


Fig 199.

the flue, thus causing a constant flow of air from the room as long as the column of gases, smoke, etc., in the chimney-flue has a higher temperature than the air that enters the vent up take from the floor of the room. In connection with this subject may be mentioned that the general plan of heating rooms one above the other by fire-place heaters has a good deal in

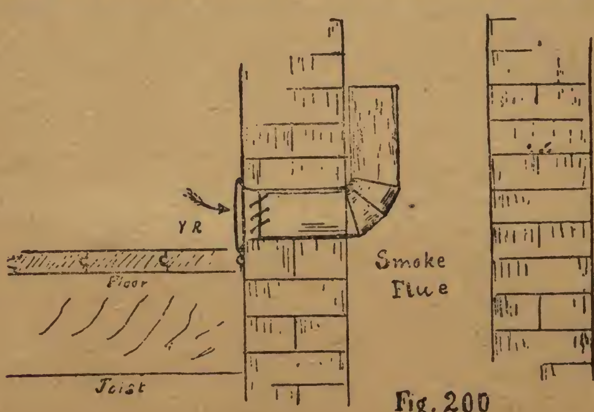


Fig. 200

common with some of the methods here shown and described. The general plan to accomplish the heating of rooms by means of heaters of this kind is as follows: In any fire-place on any lower floor the heater is set as in either A or A′ of Fig. 201. This figure shows two styles of setting, with an offset chimney and also a straight chimney. No. 1 of Fig. 201 shows the heat carried to first, second and third stories in the flues of an offset chimney; the smoke-pipe carried to the second floor, while No. 2

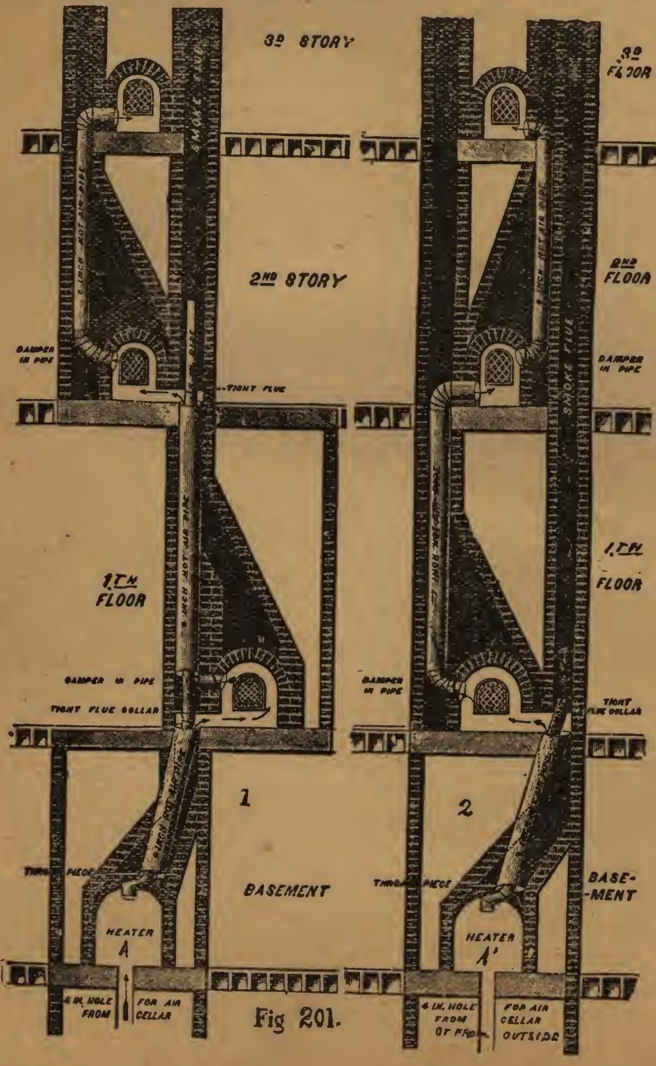


Fig 201.

shows the heat carried to first, second and third stories in the flues of an offset chimney; the smoke-pipe carried to the second floor, while No. 2 shows the heat carried to first, second, and third stories in the flues of a straight chimney, the smoke-pipe extending to the first story. Use tin hot-air pipes only, inserted in the chimney-flues for the conveyance of heat to the rooms above. Unless this is done the heat produced will be absorbed or escape in the open brick flues, and cannot be obtained in the upper rooms as desired. The fire-place in which the heater is set is lined with tin, as at A or A′ of Fig. 201. A four-inch cold air opening is to be made in the floor of fire-place, connecting with cellar or outside by a pipe for an air supply. Hot air pipes are to be used in conveying heat through the chimney flues, otherwise the heat escapes through open joints in brick work, and the rooms above are not warmed. Use, if possible, 9 in. to first story, 8 in. to second, 7 in. pipes to third. In a one-story job use 8 in. pipe to first story. Cut the withe, if necessary, so that the hot-air pipes when in position shall be straight. As the smoke-pipe goes to the first story inside this hot-air pipe, it is important to have it straight for ease in cleaning, etc.

The throat-piece in the flue over the heater, with opening in the same, is left for the hot-air pipe attachment to be placed in tightly to prevent the escape of heat except as desired. Brick up an arch-chamber behind the fire-places in which registers are placed; also have connections from the chambers to the hot-air flue made tight with mason work. See that the throat-piece, flue-collar for smoke pipe, stoppers, arches, etc., are all made tight, as a small defect at these points will prevent success in heating and allow heat to escape. Dampers to be placed in hot-air pipes on each floor to control the heat when required. Fig. 201 shows the manner of inserting hot air pipes to the chimneys. The joints of the pipes are made to lap one and a half inches, so that they can be used in sections of one or more lengths. These flues are as those generally found in buildings. Fig. 202 shows two views of one of the most used methods, namely the placing of a heavy sheet-iron smoke stack for a furnace inside of a larger square brick-built ventilating shaft. This method is extensively used throughout the country to secure efficient ventilation for school rooms, halls, churches and buildings of a like character. This system is as simple and efficient as any for the purpose, and as it is not patented it may be used by any one. The smoke pipe, as is seen, is fastened rigidly in position inside of the ventilating shaft. At the bottom end a clean-out is shown offering every chance to remove any ashes or soot that may settle at the bottom of the stack. At A′ and B′ of the side view is shown how the ventilating registers are placed in the base-boards of the room and how they connect to the ventilation shaft with an

upward turn or curve, as shown by arrows in the side view. The front view shows these ventilation registers by a face view only. More minute and detailed treatment will be accorded to this department of ventilation appliances further on, the aim at this stage being only to show the smoke flue or stack in connection with such a ventilation shaft as shown by Fig. 202.

In order to facilitate the ready figuring of the weights and cost of furnace smoke pipe connections, such as black or galvanized iron smoke pipe, vent pipes and smoke stacks, the following tables of weights, etc., are here given:

There are three grades of galvanized iron usually sold, namely: best bloom, refined and common; common is the grade mostly used for smoke pipe work, that is, for straight away stacks. For elbow work the better or more refined grades are used. The same conditions and usage are also applicable for the grades of black iron.

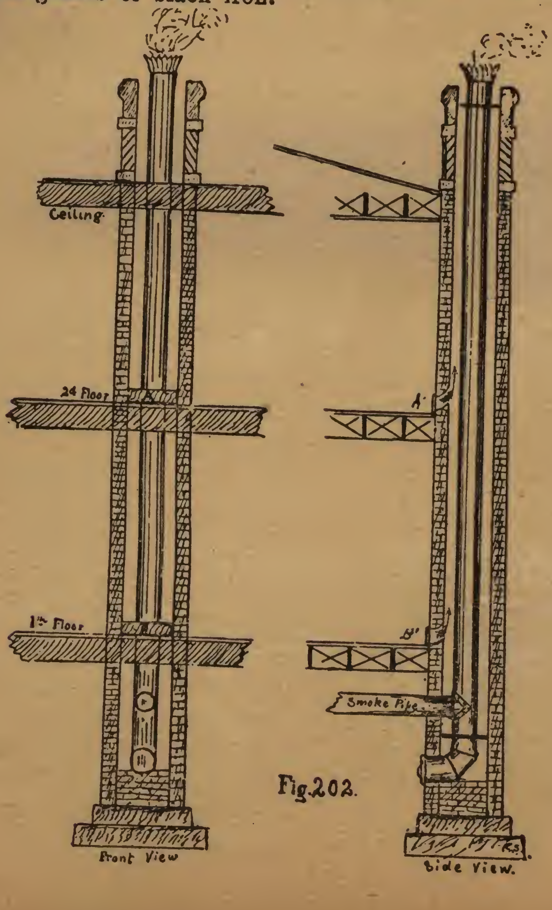


Fig. 202.

The following tables give the weight of black-sheet iron by the square foot. Table No. 1 is figured in ounces for each square foot, approximate weights of sundry plate and sheet iron by Birmingham wire gauge numbers. The gauge used in the American mills is the Birmingham gauge, arising from long custom, before there was much iron of any kind made in the United States. The American gauge is seldom used.

TABLE NO. 1.—GALVANIZED SHEET IRON.

NO. WIRE GAUGE, THICKNESS.	NOMINAL WEIGHT PER SQUARE FOOT.		NO. WIRE GAUGE, THICKNESS.	NOMINAL WEIGHT PER SQUARE FOOT.	
29	12.0	ounces.	20	27.8	ounces.
28	13.0	"	19	33.0	"
27	14.0	"	18	38.0	"
26	15.0	"	17	42.8	"
25	16.0	"	16	47.0	"
24	17.8	"	15	49.2	"
23	19.2	"	14	59.2	"
22	21.5	"	13	63.4	"
21	27.9	"	12	71.8	"

TABLE NO. 2.—BLACK IRON.

NO. WIRE GAGUE, THICKNESS.	NOMINAL WEIGHT PER SQUARE FOOT.		NO. WIRE GAUGE, THICKNESS.	NOMINAL WEIGHT PER SQUARE FOOT.	
28	9 5	ounces.	18	31.7	ounces.
27	10.8	"	17	37.5	"
26	12.0	"	16	42.4	"
25	13.0	"	15	46.7	"
24	14.6	"	14	53.5	"
23	16.3	"	13	61.8	"
22	18.2	"	12	70 4	"
21	20 5	"	11	74.0	"
20	22 7	"	10	86.8	"
19	27.1	"			

TABLE NO. 3.—BLACK IRON.

ONE SQUARE FOOT WEIGHS IN POUNDS.

0000	gauge	18 217	9	gauge	5 939
000	"	17 053	10	"	5 377
00	"	15 248	11	"	4 815
0	"	13 643	12	"	4 374
1	"	12 038	13	"	3 812
2	"	11 396	14	"	3 330
3	"	10 392	15	"	2 889
4	"	9 550	16	"	2 608
5	"	8 828	17	"	2 327
6	"	8 145	18	"	1 966
7	"	7 223	19	"	1 685
8	"	6 621	20	"	1 404

The following table will be found useful to show the amount of square feet of iron contained in 100 lineal feet of pipe of the diameters shown in the table and the number of rivets required to make 100 feet of pipe, rivets to be spaced the distance apart given in the table.

TABLE NO 4.

Number Square Feet of Iron Required to Make 100 Lineal Feet Punched and Formed Sheets when put Together.			Approximate No. of Rivets 1 Inch Apart required for 100 Lineal Feet Punch'd and Formed Sheets.
Diameter in Inches.	Width of Lap in Inches.	Square Feet.	
3	1	90	1,600
4	1	116	1,700
5	1½	150	1,800
6	1½	178	1,900
7	1½	206	2,000
8	1½	234	2.200
9	1½	258	2,300
10	1½	289	2,400
11	1½	314	2,500
12	1½	343	2,600
13	1½	369	2,700
14	1½	397	2,800
15	1½	423	2,900
16	1½	452	3,000
18	1½	506	3,200
20	1½	562	3,500
22	1½	617	3,700
24	1½	670	3.900
26	1½	725	4,100
28	1½	779	4,400
30	1½	836	4,600
36	1½	998	5,200

Table No. 5 may be found of some benefit for the ready calculation and the finding of weights in pipe work:

TABLE NO. 5.—BLACK IRON.

Size Diameter.	No. of Iron Gauge.	Weight per Running Foot.	Size Diameter.	No. of Iron Gauge.	Weight per Running Foot.
12 in.	18	7 lbs.	24 in.	12	28 lbs.
12	16	8½ "	28	14	28 "
14	16	10 "	28	12	30 "
14	14	11 "	30	14	30 "
16	16	11 "	30	12	33 "
16	14	14 "	32	14	33 "
18	16	14 "	32	12	36 "
18	14	16 "	36	14	35 "
20	14	18 "	36	12	41 "
22	14	22 "	42	14	46 "
24	14	26 "	42	12	50 "

The number of square feet in any of the ordinarily used sizes of sheet-iron are given in the table herewith:

TABLE NO. 6.

SIZE OF SHEETS IN INCHES.	SQ. FEET.	SIZE OF SHEETS IN INCHES.	SQ. FEET.
24x96 in	16.00	32x96 in	21.33
26x96	17.33	36x96	24.00
28x96	18.66	24x101	16.84
30x96	20.00	36x120	30.00
		40x120	33.33

This table is very handy when figuring up the number of sheets it requires for a certain number of square feet of surface.

These tables are as nearly correct as it is possible to make them for practical use. It will be found that in practice, when buying iron from different mills, although they may claim the sheets from these mills to be of the same gauge, there will almost invariably be some difference in the weight between the different makes of iron. A reasonable allowance must be made for this difference. If there are any variations from the weights as given in the tables, note the same and correct them so that they conform to the brand of iron that is being handled. The size or diameter of smoke pipe connections that are generally used are from 7 to 10″ for connections between the furnace and the chimney flue, while for smoke-stacks in ventilation shafts the size usually is from 10″ to as large as 20″ for ordinary cases.

In the preceding descriptions I have given directions and instructions to build and have chimneys located in relation to the furnaces, heaters, etc. These hints are all well enough if followed when building new work, but it happens in the majority of cases the furnace when set up has its smoke pipe connected to some flue or chimney in a house that has already been built years before it has ever been thought of its ever serving for the smoke outlet of a furnace. In a good many cases it happens that the chimney draft is not as perfect as it should be and there are sometimes various other causes that render the chimney flue far from adequate to perform the work of conducting the products of combustion from the furnace so that it can do the work demanded of it in the most satisfactory manner.

In the following some of the causes or poor draft, smoky chimneys, condensation in smoke pipes and other faults and failings of some chimneys are shown, and for such cases a remedy is given. I will not here discuss the reason for the issuance of smoke, whether much or little, from a furnace fire, but simply deal with the fact that there is a certain quantity of smoke from furnaces, and show some of the reasons why the chimney provided for the prompt removal of the smoke and gases produced by the furnace, does not carry away the same, as required for the satisfactory working of the entire heating plant. In the first place, to insure a draught through a

chimney flue of any kind, a certain amount of heat or heated gases must pass up and through the chimney flue, warming the flue during this passage. The reason smoke moves up through and out of a warmed chimney or other flue, is the difference of temperature between the ascending column of warmed air or smoke inside to the temperature of the air outside of the flue, and therefore in the difference in the weight of equal volumes of these columns of air. As long as the temperature of the smoke, gases, etc., is higher than that of the outside air, there will be a constant movement of these gases upward. If no heat is presented inside of the flue above the temperature outside, there can be no draught upward in the flue unless caused by a current of wind outside of the chimney. To produce heat for the purpose we must have combustion, and in order to support the combustion means must be provided for supplying the furnace with a continuous supply of air and for removing the products of combustion. Both of these objects are accomplished by the chimney; the products of combustion in their heated state being lighter than the external air, tend to rise through the flue, and drawing air through the furnace, supply the required oxygen, the remainder, with the products of combustion, passing off in their turn, and, by reason of their lightness, to maintain the draught.

The conditions defined scientifically under which the heated column causes an up draught are these: the draught merely represents the velocity with which the air is traveling through the shaft of the chimney, and all arrangements should be thus made with a view to develop the formation of that upward velocity. In the column of hot air the velocity of up draught is generated simply by the difference of specific gravity of the hot air in the chimney, as compared with an equal column of cold air in the external atmosphere. The cold column, of heavier weight, by the well-known law of gaseous and fluid pressure, displaces the hot column from the inequality of pressure at the base of the chimney, endeavoring to produce equilibrium. As, however, every succeeding supply of cold air becomes heated in its turn as it passes through or over the fire, the constant circulation is maintained, and the result is a draft. The intensity or velocity of this draft is determined by the rise in temperature of the ascending column of air and by the smallness of the passage or shaft through which the air is traveling, so long as the passage is not too small to choke the draft.

Thus it sometimes happens that newly-built chimneys, which have not been cleaned out of the mortar, pieces of brick, etc., which have been dropped down in the flue of the chimney by careless and negligent masons while building the chimney, sometimes choke up the passage so that there is hardly any draft. The remedy is to clean out the obstructions. Then

again, it often occurs that a newly-built chimney will not draw because of the walls being damp. This chills the ascending column of gases and almost entirely stops the draft, or at least causes the draft to be very sluggish. The same condition is often present in old chimneys, caused by their being placed in much exposed portions of a house, such as in outside walls.

When the chimney is in the outer wall, the side toward the street or open air is generally very thin, sometimes not more than four inches thick, and a considerable portion of heat passes through this slender side into the open air. After a shower of rain that part of a gable of a house through which the chimney runs dries more rapidly than the other parts. This shows that the heat is coming through the side of the chimney and getting out of the house, instead of warming the interior and higher parts of the flue so as to maintain a draft. This could be helped by making the walls thicker and heavier.

The foregoing appeals particularly to that part of the chimney stack above the roof. The principal object in its construction is to maintain throughout its warmth, as it is there, of course, exposed to the cold and damp; and it is well known and observed that those chimneys which are in external walls are from this cause far more liable than others to smoke. Pervious brickwork becomes saturated by rain, and the flues, consequently reduced in temperature, are unable to maintain the requisite upward draft. It is well, therefore, for this reason, as well as for additional strength, that the chimney stacks above the roof should be built in cement instead of common mortar, and of impervious bricks or stone. The tops of the chimney stacks need careful arrangement, because the exit of the smoke from them is very liable to be disturbed and hindered by gusts of wind, particularly when their tops are commanded by higher buildings, or by a hill, so that wind blowing over them falls on the tops of the chimneys and beats the smoke down. If the chimney cannot be raised so that the top may be of the same height, one remedy is to mount some kind of a chimney cap. Avoid all fixtures that will aid in cooling the smoke and gases as they come near the point of exit, and, if it is thought best to elongate the chimney flue by the use of an iron pipe, instead of using a chimney cap, such structure should be a double cylinder, with air space between, in order to maintain the heated temperature of the smoke and gases until they pass out; and in all attempts to cure a smoky chimney it should be borne in mind that, to procure a proper chimney draft to burn concentrated fuels, the heat within the flue during the coldest days of winter should be sufficient to evaporate water within 12 inches of its top.

Leaks in the chimney and masonry about a furnace have a decided and

prejudical effect upon the draught, not only from the fact that air enters at those places which would otherwise come through the grates, but the air so entering is cold and heavy, and increases the weight of the column of air in the chimney, instead of reducing it as it would in its rarified condition after passing through the fire.

Care should be taken in making more than one connection to a flue, first to have the leading flues so constructed that one may not have a decided advantage over the other, and second, that they do not enter the stack in such a manner as to interfere with each other. When flues enter a stack directly opposite to each other, deflecting plates should be provided in order that the entering currents may not oppose each other. In large stacks with flues entering upon all sides, a cone is sometimes built in the center of sufficient height to serve as a deflector.

It frequently happens that a draught which has been sufficient becomes impaired and unable to do what is required of it. The first and most natural cause which is looked to in this dilemma is obstruction, by the ac-

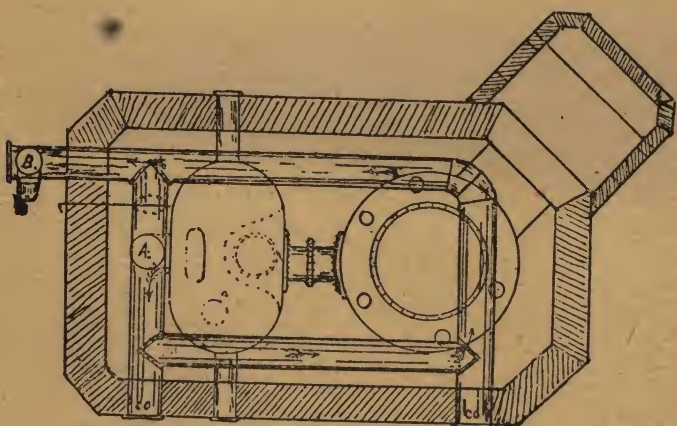


Fig. 194.

cumulation of soot in the flues and passages. If this soot is also deposited in the tubes and upon the heating surfaces of the furnace it diminishes the efficiency of the coal which is burned by interposing itself as a non-conducting coating between the fire and the heating and radiating surface of the apparatus which it is designed to heat, rendering necessary the consumption of more coal, requiring a stronger draught, which the passages in their choked condition are unable to supply.

The draught of a chimney is, of course, affected by the character of an apparatus which is attached to it, and of the flues or passages through

which the heated gases are conveyed to it. A plain cheap and direct flue furnace will not require as strong a chimney draft as a more complicated and more powerful heater would, as shown by the Figs. 194 to 196.

In cases where, as it frequently happens in city blocks, the furnace is situated in front and the chimney in the rear, a long and tortuous flue, sometimes descending, is used, allowance must be made not only for the increased friction of the flue itself, but for the heat which will be radiated from it, and which would otherwise assist in sustaining the chimney draught. This feature of having such long smoke pipe connections causes the gases passing through them to chill and the aqueous vapors to condense, causing the pipe to rot and rust out in a short time and also greatly retarding the draft by reason of their being chilled. The remedy is to wrap the pipe with asbestos sheathing. This will, in a measure, help to increase the chimney draft.

Air and gases expand almost equally and nearly in proportion to their increase in temperature; and as this law of expansion applies to air in motion the same as to air at rest, we can calculate the amount of expansion of a column of air in a chimney flue from the heat of the stove. But as this heat varies, so also does the heat contained in the volume of ascending air and gases. The air that passes through a fire undergoes a chemical

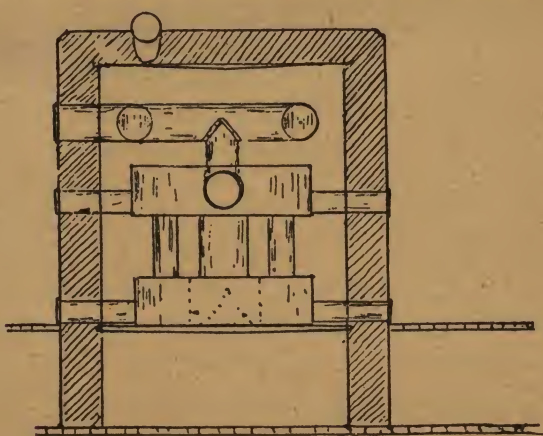


Fig 196.

change, becomes intensely heated, and, as it passes through the stove pipe to a chimney, becomes reduced in temperature; and, if the pipe is too long, or if it is composed of too many crooks, no heat can reach the chimney and we have a poor draft for the reason that one of the gases produced by combustion, when cold, is heavier than air, and will so fill the chimney

flue that the lighter gases cannot pass through it.

The following are a few of the remedies to cure smoky chimneys that will not draw. One is to lengthen the chimney at the top. This increases the quantity of heated air in the chimney, and gives more power or head by increasing the difference between the weight of the air per foot in and outside of it. Another plan is, if there is a deficiency of air supply to the fire, to correct this by placing ventilators or other suitable means to supply this deficiency. Then the almost universal method of curing smoky chimneys that will not vent well is by using some sort of a chimney cap. As shown in some of the foregoing statements the draft of a chimney depends upon the difference between the temperature of the heated air contained inside of the chimney and that of the outside air upon the height of the chimney, and other causes. There may also be cases where some object at or near a chimney may cause a strong gust of wind to blow directly down a chimney flue, carrying and forcing the smoke back. It may also be desirable at times to force or draw air out of a chimney that is colder than the outside air. It has been stated that the draught of a chimney is decreased by the sun shining upon it, and I have read the most profound arguments to the effect that it was retarded in some way by the actinic rays acting down upon it. If any such effect is produced by this circumstance, I should be inclined to lay it to the lightening of the external column of air rather than any direct retardation of the inner one.

To overcome the sluggish and insufficient draft in chimneys, if caused by some of the foregoing conditions enumerated, such as no draft, down draft, etc., the following suggestions are submitted: Fig. 203 gives an

FIG. 203.

illustration of how currents of air and wind act when they strike or come in contact with a chimney viewed by a plan view.

The currents of air as shown by the arrows strike the chimney at A then diverging from the side or from the end of the obstruction such as the chimney really presents to the current of air, they by their impetus, whatever that may be, according to the velocity with which they are moving at the time such contact occurs, take a lateral direction toward the sides B B, passing beyond the sides or ends somewhat, the diverted currents coming in contact with the main current, this causing the two currents to assume a direction somewhat diagonal to them both, but are gradually forced back to the original normal current at some distance beyond the chimney as shown at C of Fig. 203. The currents flowing past the two sides, as at B B, do so at some distance from the chimney and cause the air in this space to flow out from it and with the current flowing around the chimney, causing a partial vacuum at the spaces B B and the back at C.

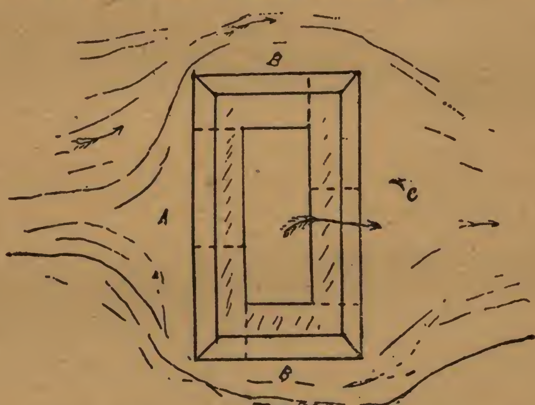


Fig. 203.

If there are any openings in the chimney for the ready exit of smoke it will readily flow into the spaces to fill the vacuum, then in turn being drawn along by the outside currents of air, the constant flow and passage of whatever smoke is in the chimney is assured at all times when there are currents of air around the chimney at that part where the smoke makes its exit. The side view or elevation, Fig. 204, of the plan, Fig. 203, shows the course which the currents of air have in connection with the chimney when seen from this point of view. The currents striking the chimney at the side at A take the course as the drawing shows, upward and over the mouth of the chimney, thus producing a good draft and strong flow from the chimney flue if the latter is of the correct size for the work required of it. The air currents taking the upward course shown by Fig. 204 effectually shield and prevent the horizontal current flowing along the top of the chimney from flowing ahead in that direction, but they at first are forced

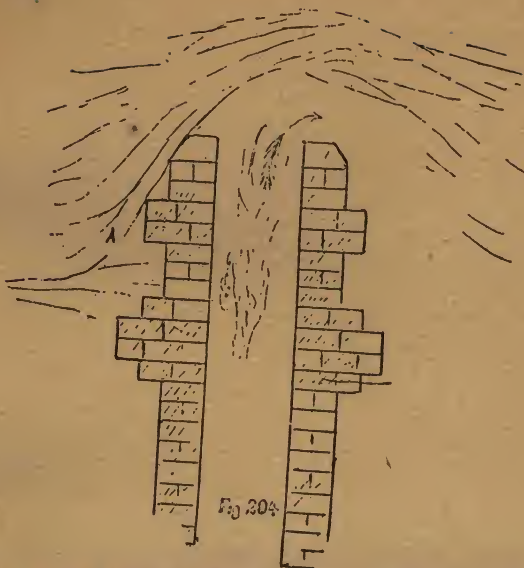


Fig 204

to take the same course that the upward current has until finally the horizontal currents break and overcome the force of the upward currents and both again resume their normal course. As will be seen in the drawing, Fig. 204, this does not occur until the currents have passed over and are at some distance beyond the chimney, thus providing ample room for the column of smoke and heated gases to flow out from the chimney.

One of the oldest styles of appliances to increase the draft of chimneys is shown by Fig. 205. This may be briefly described as consisting of a large casing, square or rectangular, if the chimney be so shaped, or if the chimney is round the outside casing would of course also be in that shape. The idea of placing this outside casing around the outlet of the chimney is that it increases the power of the currents of air flowing upward and thereby affords a greater space for the smoke to flow into. The action that causes this is as follows: Part of the current A strikes the shield B and flowing up and above it causes a partial vacuum; then that part of the current, as C, entering below the lower edge of the shield or casing, at D, flowing into the partial vacuum of this space, passes through it with considerable velocity and encountering the current above forces it up and away still further and higher from the top of the casing B, of Fig. 205,

This causes a greatly increased flow of smoke, etc., from the chimney in this top case.

There are also cowls made of the class shown by Fig. 205 which are provided with a plate as the dotted line E of this figure shows. The object

of placing it in the position given is to prevent any possible down drafts.

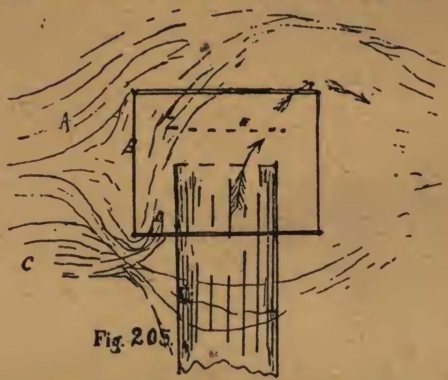


Fig. 205

The direction which the currents take through the cowl when they strike the same in a downward direction are not shown in the figure, but the plate E put to the cowl has the effect of making the same as near perfect as possible so as to prevent currents from striking and entering the top of the flue. By Fig. 206 is shown a ventilator and smoke cowl. This style is called the Espy ventilator. The top part, A, turns and is so arranged

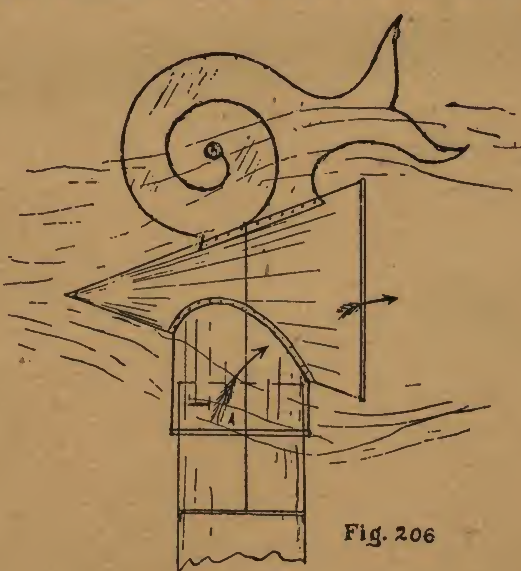


Fig. 206

that the wind will at all times keep the mouth, or open end, from the direction in which the wind is blowing. The wind blowing toward the apex

of the conical part of the hood passes by this on each side, and does not

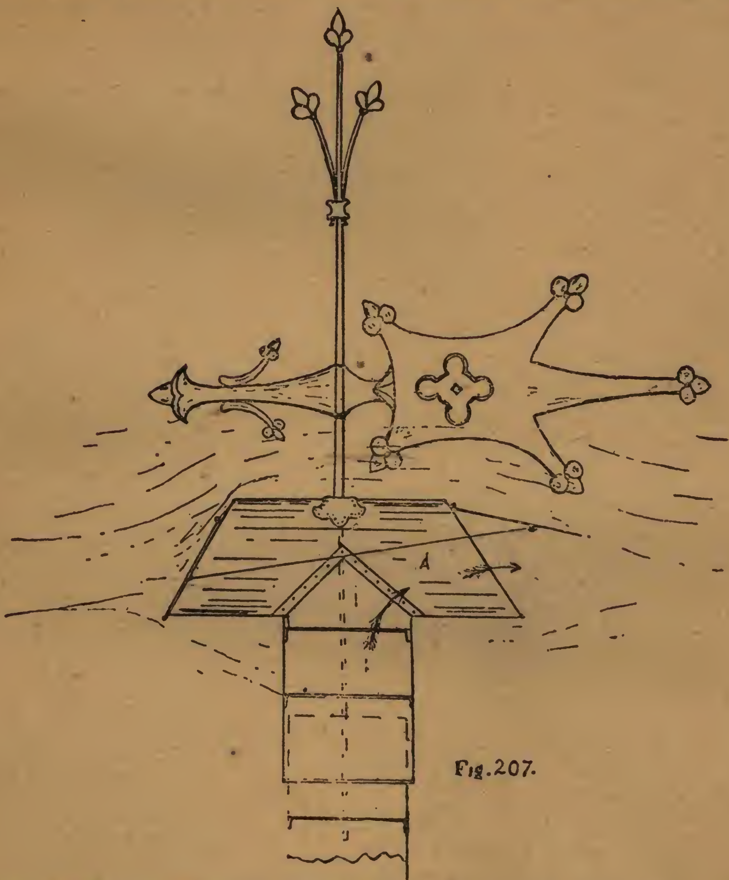


Fig. 207.

meet again for some distance beyond the open mouth of the cone. This causes a vacuum, and consequently a draft is established from the flue through the cone and out. Fig. 207 shows another style of chimney caps This consists of two cylindrical parts joined together as in the figure. The horizontal part, A, has both ends cut at an angle; a light cover is provided for each end of part A, hinged, and these covers are joined by a rod which causes the two doors to stand open when there is no wind, but when it is blowing the door which is on the end nearest from which the wind is blowing closes, and at the same time opens the opposite door. The drawing shows the course of the outside as well as the inside or smoke currents from the hood. This style is also made to turn by the force of the wind, a

rather ornamental vane being shown put on the hood in this instance. One of the principal objections to hoods and cowls, as the Figs. 206 and 207 delineate, namely, such as turn, is that there is always some danger that unless the bearings are properly arranged they become clogged and sticky by deposits and rust. This point must be provided for to avoid the disagreeable nuisance which a chimney cone is when stuck or fast so that it will not turn. Numerous devices have been invented to meet just this condition, and almost any ingenious mechanic can, with little study, overcome this difficulty. The chimney cap shown by Fig. 208 is a stationary

Fig. 208.

style. The main parts consist of two cylindrical pieces joined together. The two end doors hung to the horizontal part at the top are hooked together by the rod A, which prevents both doors from closing at the same time. The direction that the currents of air have are shown by C. The small cone, B, is merely put onto the cap for ornamental purposes. Fig. 209 is the old reliable Emmerson chimney cap. This form of cap has been invented more than fifty years and it forms with some of the styles given the foundation principle from which most of the patented hoods now on the market are derived. The Emmerson top has most of the desirable features a first-class chimney cap should have. It costs less than most chimney caps, and any furnace-man can make one on short notice. It works every turn, and never obstructs the draft. The conical top deflects the wind upward, forming a shield; then striking the flat top, it spreads out in a thin horizontal stream, carrying along the air in the flue. The width of the flaring portion is equal to the diameter of the flue. The top is set so

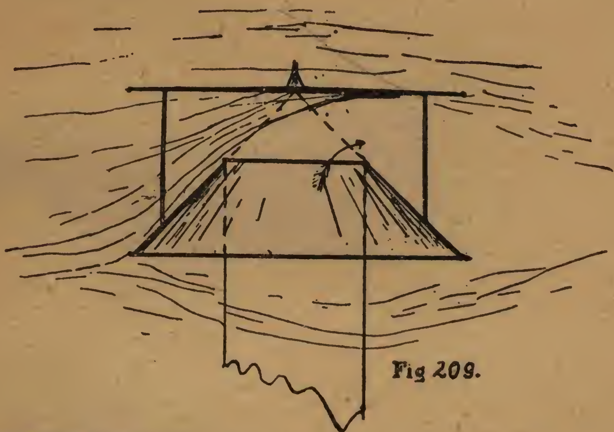


Fig 209.

that it would rest on the apex of the cone, if completed, and is held up by three or more upright supports.

The styles described offer a sufficient variety of cones for the furnaceman to cure almost any smoky chimney that may be met with in ordinary practice, that is, if the cure is to be effected by the means of a chimney cap. Some suggestions how to reduce the danger from fire or overheating of smoke flues and pipes, connections, etc., to a minimum would perhaps not be out of place at this time. Furnace smoke-pipes should be thoroughly cleaned, and all unsound lengths replaced by new ones. All pipes should enter good brick chimneys, and should enter the chimney horizontally. Where dust is liable to accumulate, the horizontal pipe lengths should be carefully riveted together, and an additional pipe placed outside, leaving at least one inch air space between the inner and outer pipes, supported at frequent intervals by wires, also well wired to hold it in the chimney. In all cases where pipes pass through wooden or lath and plaster partitions, there should be a double collar of metal, with from two to four inches air space, and holes for ventilation, or at least eight inches of masonry about it.

The chimneys should be examined carefully, especially where they pass through floors and roofs, as the settling of the building may cause cracks that would let sparks escape. A long-bladed case knife serves well as a probe for this purpose.

All pipe holes not in use should have close-fitting stoppers. There should be no woodwork of any kind framed into the chimney; and the entire surface of the trimmers and headers next the flue should be entirely covered with tin or light sheet iron.

Ashes should always be placed in a fire-proof receptacle when taken

from furnaces. Any woodwork nearer than 18″ should be covered with asbestos paper, and then covered with tin, or protected in some equally safe manner. The flues should be examined from time to time, and if any soft or unsound bricks are discovered they should be taken out and replaced by sound ones. Of course no intelligent man will allow any joists, etc., to be anchored or built into chimney walls. Even if some of the bricks separate the woodwork from the hot flue there is more or less danger. Have the wood away from the chimney, if possible. It has been proven by actual occurrences and by good authorities, that by long exposure to heat not exceeding 212 degrees timber is brought into such a condition that it will fire without the application of light, and when finally started the source of the fire would perhaps be in such an awkward place that even if discovered in an early stage it could not be reached without considerable damage to the premises.

XIX.

COLD AIR SUPPLY.

The cold air supply for furnaces, the methods and appliances by and through which fresh air is conveyed to the heating apparatus, is the subject of this chapter. The functions of cold air ducts, air chutes or cold air boxes for furnaces, is to provide a suitable and adequate channel for the passage of cold and fresh air from the outside of a building to flow through and to the bottom of the furnace. From this point the air flows up to replace the heated and ascending volume of air in the air chamber of the furnace. The constant supply of fresh and colder air which is flowing into the furnace chamber is, in its turn, heated by radiation in the chamber between the heated surfaces of the furnace proper and the outer wall or lining of the chamber. It then rises. This is caused by the increase in bulk by expansion, owing to the heat it has absorbed from the heated plates of the furnace. Against this volume of heated air the succeeding volume of colder or denser air presses, causing a continual passage of cold air through the air duct to the furnace. This movement will occur as long as a fire or a greater degree of heat is present in the furnace chamber than the source of supply at the mouth of the air duct or the outside air has, if suitable outlets are provided for the passage of this volume of heated air from the furnace to the rooms above, and, again, if these rooms are pro-

vided with properly proportioned and arranged ventilating outlets for the prompt removal of the cooled and vitiated air from the rooms supplied.

I will give a few of the most pertinent reasons why such a change of the air is demanded: These are, first, to provide for the constant renewal of a volume of fresh or pure warmed air in the rooms of a house heated by a furnace so that the purity and proper standard necessary for the health of the occupants can be maintained at a degree of warmth consistant with their comfort; second, the duration of such occupancy and the amount and nature of the impurities in the volume of air, resulting from various causes, which tend to contaminate the air more or less, even in some instances before it is drawn or passes into the cold air duct to be used. Then the impurities resulting from the respiration of the occupants, lamps, fumes from various other sources, dust and other causes; all these are factors which tend to vitiate the air in the apartments, and this air when drawn out from them through the ventilating shafts or ducts can only be replaced by the fresh, pure air which is drawn or is passing through the cold air duct, then warmed and delivered into the rooms, if all the functions which this volume of air is to perform are to be fulfilled. Other reasons, perhaps not as weighty as those mentioned, could be cited, but I will reserve these for more detailed treatment further on. Enough has been mentioned to give the student a fair idea of what importance the cold air ducts are to the proper working of a warm air furnace, and the prompt renewal of air for the rooms to be heated and ventilated. This air for the rooms above should be changed at least three or more times an hour, this depending on how much space there is to heat and also on the number of persons occupying the rooms at one time. In the following will be found some of the reasons why the heated air rises through the furnace, and how the air acts if heated to different degrees of temperature. One of the first effects produced by heat on any certain column of air is that it expands and for a given weight increases in volume or bulk but not in weight; that is, the volume of air being heated does not become any heavier, but it occupies a larger space than it did before it was heated and rarified. The colder air, retaining its normal bulk, and consequently its common density, forces the warmer and lighter air forward and upward the same as a cork is caused to float and is pushed upward if immersed in water. The normal pressure of the atmosphere on the surface of the earth at a mean temperature is 14.7 lbs. per square inch; thus we have the cause for the upward movement of a heated column of air by the difference in weight and density between it and a column of colder air of the same volume.

From the following tables and data may be deducted: first, the correct size to make the inlet of cold air in proportion to the outlet from a

furnace; second, the rate of movement of the air and the volume it has at different degrees of temperature; also the weight of any volume of air at different temperatures:

TABLE OF THE EXPANSION OF AIR FROM 32.8° BELOW ZERO TO 772° ABOVE.

(DALTON.)

TEMPERATURE.	EXPANSION.	TEMPERATURE.	EXPANSION.
— 32° 8°	.8650	85°	1.121
0°	.935	90°	1.132
12°	.960	95°	1.142
22°	.980	100°	1.152
32°	1.	120°	1.194
33°	1.002	140°	1.235
34°	1 004	160°	1.275
35°	1.007	180°	1.315
40°	1.021	200°	1.354
45°	1.032	212°	1.376
50°	1.048	302°	1.558
55°	1.055	392°	1.739
60°	1.066	482°	1.912
65°	1.077	500°	1.954
70°	1.089	525°	2.001
75°	1.099	680°	2.028
80°	1.111	772°	2.312

TABLE OF THE VOLUME, PRESSURE AND WEIGHT OF AIR FROM ZERO TO 3,000°.

(HASWELL.)

TEMPERATURE IN DEGREES.	VOLUME OF 1 LB. OF AIR AT ATMOSPHERIC PRESSURE 14.7 LBS.	PRESSURE OF A GIVEN WEIGHT OF AIR.	DENSITY OR WEIGHT OF ONE CUBE FOOT OF AIR AT 14.7 LBS.
0	CUBIC FEET.	LBS PER SQ. INCH.	LBS.
0	11.583	12 96	.086331
32	12 387	13.86	.080728
40	12.586	14.08	.079439
50	12 84	14.36	.077884
62	13.141	14.7	.076097
70	13 342	14 92	.07495
80	13.593	15.21	.073565
90	13.845	15.94	.07223
100	14.096	15.77	.070942
120	14.592	16.33	.0685
140	15.1	16.89	.066221

160	15.603	17.5	.064088
180	16.106	18.02	.06209
200	16 606	18.58	.06021
210	16.866	18.86	.059313
212	16.911	18 92	.059135
220	17.111	19.14	.058442
240	17.612	19.7	.056774
260	18.116	20.27	.0552
280	18.621	20 83	.05371
300	19.121	21.39	.052297
360	20.63	23.08	.048476
400	21.634	24.2	.046223
450	22.89	25.61	.043686
500	24 146	27.01	.041414
550	25.403	28.42	.039365
600	26.659	29.82	.03751
650	27.915	31.23	.035822
700	29.171	32.635	.03428
750	30.428	34.04	.032865
800	31.684	35.445	.031561
850	32 941	36.85	.030358
900	34.197	38.255	.029242
1000	36.811	41.065	.027241
1500	49.375	55.115	.020295
2000	61.94	60 165	.016172
2500	74 565	83 215	.013441
3000	87.13	.27.265	.011499

Dalton gives the following data for the expansion of air. One cubic foot of air at or from 32° or the freezing point taken at 1 or unit at 100° its bulk is 1.152, an increase of 152-1000, equal to an increase of three-twentieths of the original cubic foot or bulk. When heated to 482° its bulk is 1.912; when heated to 500° its bulk is 1.954, or a little over nineteen-twentieths of the original bulk or what the cubic foot of air was at 32°. From the foregoing the deduction may be drawn, and which is near enough correct for all practicable purposes, that for every degree which air is heated from 32° to 525° it increases 1-494th part of its bulk nearly. Again, if we take air at zero the volume of one pound is 11.583 cubic feet; at 120° it is 14.592 cubic feet, an increase of a little over three cubic feet over the bulk the air had at zero. Box gives experiments with a volume of air by Dulong and Petit. Air at 32° above zero, by experiment, 1.000 or unit, at 32.8° below zero, by experiment, it has a proportionate bulk of 8650—by calculation, 8678; at 482° above zero, by experiment, it is 1.9198—by calculation, 1.918. Comparing the quotations of other authorities with the above, Dalton and others, they give air at zero equals .935; at 32° above zero equal to 1; at 122° equal to 1.184; at 500° equal to 1.954; at 525° equal to 2.001, and at 550 equal to 2.056. From the foregoing it will be seen that these authorities differ somewhat in their deductions and figures from each other in some particulars as to fine and delicate scientific distinctions, but as to the practical application for furnace work

there is not enough difference in the quotations to hinder us from averaging at near enough results for use from the deducted data that these authorities give, and this without a great amount of elaborate figuring. Taking zero as the mean, as the weather does not usually get much colder than zero for any length of time in most localities, it is safe to take zero as a basis to work on for the lowest degree of temperature that the air is to be admitted to and through the cold air duct to a furnace. As I have stated before, a furnace should never be heated to a higher temperature than from 400° to 500°. This insures with a well-designed and properly built furnace a sufficient amount of heat from the same to heat the air passing through the air chamber from zero to 120° up to 200°. I will take the lower figure, 120°, as the degree of temperature at which the warm air is to leave the starters or outlets of a furnace. As the table shows, air at zero has a volume of 11.583 cubic feet per pound, and 120° it has 14.592 cubic feet, or a little over 3 cubic feet more. As 3 cubic feet are six-twenty-ninths nearly of 14.592 and 11.583 cubic feet are twenty-three-twenty-ninths nearly of 14.592 cubic feet, it follows that the cold air inlet should be six-twenty-ninths smaller than the outlets are, the air assumed to be at inlet at zero and at outlets at 120°. To use a still more simple rule one-fifth will do for the difference between the inlets and outlets as deduced by the foregoing data. The method given is a simple and quick way to ascertain the proper proportionate size a cold air box or inlet should be to the outlets from a furnace. The figures give the size considerably larger than some furnace men allow this feature in furnace work. I may add, at this instance, that right here is to be found the reason and source of a good many failures in furnace work which explains why furnaces do not send up more air, heat, etc. The reason is that the cold air duct in many cases is made too small for the proper fulfillment of the work demanded of it.

By the foregoing tables it is seen that the warmer the air is which enters the air duct compared to that of the out-flowing air from a furnace the more sluggish the outflow and the less power and force is left to the cooler air to force the warm air out from the furnace's hot air chamber. This proves how wrong and fallacious is the method advised by some furnace men, namely, the system of warming the cold air before it is delivered to the furnace and used for the heating of the rooms above. Another method, equally as ineffectual, is to take in the cold air at the top of a brick-set furnace, leading it downward and then up through the hot air chamber proper. When it finally leaves the furnace it does so at a greatly diminished rate of speed from what it would have if taken into the furnace by the way that common sense would suggest, viz.: at

the bottom, in order to ensure the best results. The average of discharge of warm air from a furnace if heated to 120° is at the rate of five feet per second. The foregoing data gives the actual size that an air duct should be made if every advantage is to be given a furnace so that it will work smoothly and easily as far as it is in the province of a proper sized air duct to aid to this end. An air duct can only be figured to the area or size that the smallest part of the duct is. This makes it necessary that the duct be made smooth and of an equal area throughout its entire length, so as to avoid any considerable friction and to have no contraction at any point smaller than the area at which it is figured. In these calculations no provision has been allowed for any of the possible causes of a diminished flow in the duct, such as friction, etc., on the inside surface.

In my own practice I have found that it is always the safest plan to have the cold air duct large enough to fully answer any demands that might occur, and which it would have to meet. As the outside air is cheap I may venture to assert that is cheaper to heat a somewhat larger body of air to a moderate degree to warm a certain space than it is to heat a small volume to an intense degree for the same purpose, this last operation costing more and, besides this, it deprives the air of some of its most vital properties, such as certain vapors and ozone, by reason of the air being heated to such a high temperature. The best practice is to give the furnace enough air for all and any requirements, thereby avoiding the furnishing of the extra amount of heat which the furnace must supply to overcome the fault if too small an amount of area for air is allowed at the inlet or cold air duct. In my own practice, notwithstanding all the authorities given, I never reduce the area of a cold air inlet or the supply to less than one-sixth of the total area of the entire outlet from a furnace. In case the air during its passage through the cold air duct has many corners to turn and if the sides of a duct be uneven and rough, thus causing friction, eddies, etc., in the flow of air, the policy of having such a proportion for the size of a cold air duct is at once apparent. I have found this standard of proportion the very best to work well in all cases where I have used it for cold air boxes to furnaces. If it should happen that the temperature falls below zero or if a strong wind blows directly toward the mouth of the cold air duct all that is necessary is to close the shut-off slide somewhat which insures a complete control of the supply. On the other hand, I will assume that a cold air box had been built to the proportions best suited for the lower temperature, then if the weather becomes somewhat milder, say to about 30° or 40° above zero, it is clear that the more power and heat would be required and also more area or section for the air box to keep up

the same rate of flow through the pipes than would be present for this purpose, calculated for the denser or colder condition of the air. Then assume a cold, muggy, disagreeable day, with perhaps a chilly wind blowing at times in a direction contrary to which it is desirable it should to best supply the cold air duct. To sum up, for these reasons it is policy and good practice to make the air duct large enough so that it can take all the air it needs to supply the furnace properly; all this without forcing the fire or heat in the furnace, as this requires more coal, or in other words, more money must be expended to operate the furnace under these conditions. If the means indicated in the foregoing to control the air inflow are adopted, it will result in the perfect working of such an apparatus.

In connection with the regular air duct for a furnace it is often the practice to take a partial supply of cold air from the coldest room or hall of a house. This in some instances is allowable where a house is poorly built, as the case may be when cold air is constantly flowing in, and by loosely fitted doors, windows and casings. For this style of connection for the cold air supply to a furnace very large register faces and ducts are required, because the supply will not be so rapid and abundant as if it were taken from an outside air duct. In fact, in some cases this course of air supply would not do at all, for the reason that the supply would not be as pure and fresh as a supply from the outside of a house. The air being brought down from the rooms above would be but a case of using the air over and over again, and thus almost defeat the chief end and purpose of ventilation, which is at all times to supply and maintain the standard of purity and freshness of the air inside of the house equal to that which surrounds the same outside. This desired end can only be accomplished by conveying the air into the furnace in a house by means of a cold air duct, the air then being heated and conveyed to the rooms above, which is the only proper way to do this. The large register face usually used for a return duct often tends to draw a strong current of cold air from any inlets that may be present around the front door of a hall. This is one of the bad features that this style of arrangement has, and one particularly its own. It is often the case that a hall return duct is put in to take the cold air out from a hall, as the argument is that it is generally advanced by the advocates of this practice, but in a good many cases the arrangement will not work. This is generally owing to the fact that the connection to the heater is not made correctly, because the workman putting the connection up in most cases does not know how it must be done so that it will work properly. I will give a detailed description how to accomplish this further on. A hall return pipe can seldom be made to work properly by uniting it with the outside duct. It must have a separate and peculiar arrange-

ment fitted to the furnace to insure its working at all times; this arrangement in some cases costing a sum quite out of proportion to the benefit secured by the owner, considering the first cost and the danger of using the same air over and over again, which may possibly have been contaminated to some extent, and all this when fresh, pure air could have been had for little or no cost at all.

No possible arrangement of taking air from a hall can secure the direct, positive movement of air that would be as satisfactory as that of the air taken from the outside of a house through a cold air duct. There are cases, such as for halls, churches, schools, etc., where the use of a return air supply for a furnace may be permitted. This can supply the needed air to the furnace, when the rooms are not occupied, to keep up the circulation, but their use must not be permitted under any circumstances when the rooms are in use. The cold air must be taken from outside of the building, and it is to be seen to that it is as sweet and pure as it can possibly be obtained. Having shown how much air must be supplied to a furnace by means of a cold air duct in relation to the proportions that the outlets have —these, as a matter of course, being proportioned to the power or ability of the furnace to heat the amount of air passing through the furnace—a complete treatment of this subject will be given further on. The next division that I will discuss of this subject of cold air ducts will be the mechanical part, such as the different kinds and styles of duct, the kinds of material used in their construction, their location and all the various details entering into their making and fitting up.

The first consideration when planning a cold air supply duct for a furnace is to locate the mouth or opening of the duct at that side of a house which faces in the direction from which the prevailing winds blow; particularly is this applied in case a house stands alone and where the wind has a a good chance to sweep and flow around and about the building, thus often causing counter-currents of air which would tend to operate in direct opposition to a cold air duct if the opening for the same were not located on the side against which the wind blows. The direction from which the wind blows in most parts of this country is from the north or west and the opening or mouth for a cold-air duct should always be placed accordingly. In houses in city blocks, where the surroundings do not permit the placing of an inlet for the duct according to the above directions by reason of the houses being enclosed and other buildings abutting against them, the rule must be set aside, but as it does not matter much in such a case which way the wind blows, the houses being for the most part enclosed and sheltered by the other buildings surrounding them, the only important point to bear in mind in such a case is to have the inlet in such a position

so as to supply it with the purest and freshest air obtainable in the neighborhood in which the house is situated. This implies that it is not good practice to have the inlet located under some porch or near some waste water drain, or in some musty, damp corner, but instead every precaution and earnest, intelligent effort should be brought to bear to this end that the source of supply be the best possible to be had and as free from contamination as human ingenuity and foresight can make it. Thus only can a perfect job be done as far as a perfect cold air inlet tends to make it so for such a house. As to the quality of the air if the supply is taken from a hall as an auxiliary to the cold air inlet from the outside of a house, or if the entire supply is taken from a cellar, it depends entirely upon the cleanliness and condition of these sources of supply. If the cellar is perfectly clean, dry and tightly cemented, with no occasion for it ever being in any other condition, it may be permissible in some cases to take the air from that source for a furnace, but I am rather inclined to advise against this method. In case the air-duct inlet be so situated that if a window were taken out from the cellar and the opening left were used for the mouth of the duct, and owing to the position and location that this opening had it would be in a direct line or sweep of the wind, which would be liable to carry considerable dust, etc., along and down the air duct, at times it would be a good plan to turn the cold air shaft up a couple of feet and have its mouth protected by a hood to prevent snow, rain, etc., from blowing into the duct. A $\frac{3}{8}''$ to $\frac{1}{2}''$ mesh galvanized wire screen is to be fastened over the mouth to prevent any loose paper from being blown in down the duct, also to prevent any rats or other animals from entering the duct at any time. In the foregoing I have shown how to find the correct size for any cold-air supply duct, basing the calculations for this end upon the size of the outlet from a furnace. These are to be correctly proportioned so that the amount of fresh heated air delivered by them under all circumstances is sufficient, so that it can be inhaled without injury to the health of the persons occupying the rooms to which the warmed air is delivered by the furnace. A full treatment will be accorded this subject under the head of ventilation, giving all the data as to the proper sizes of inlets to rooms for the warm air supply, amount of air required for each occupant, how to measure the flow of air, etc. When taking air from a hall for some buildings in conjunction with an outside inlet the supply pipe need only have fifty per cent as large an area as given for the direct outside supply, because at night, when the hall pipe is most used, a considerable less amount of heat is required throughout the house, and, as a consequence, a less quantity of cold air is ample to supply the demand at such times, thus a smaller size pipe is sufficient for the return, the outside supply being

shut off. One point in particular to be noted when using a hall return pipe in connection with the cold air supply duct from the outside, is to have the two branches so arranged that they can be shut off perfectly tight from each other so that no back action of the air occurs into the powerful hall pipe. This frequently occurs when it is attempted to use both sources of supply at one time. One only should be used at the same time if the best results are to be obtained from such an arrangement as is generally put in for the purpose. The only way by which it is possible to obtain a positive movement through the return cold air pipe from a hall even when the outside supply duct is open, is to have the return pipe enter the casting of the furnace at the lowest possible point independently from the outside cold air duct, then turn the return pipe upward a sufficient distance so that it will become heated, thereby heating the air and causing a draft upward through the furnace and also a corresponding downward flow of air through the cold air return pipe from the hall. It often happens, even if the cold air duct, the outlets and the other parts of the work which a furnaceman has to do about a furnace are all done according to the best rules and practice known, to him still the air does not seem to flow through the apparatus as it should. A good many reasons may be found and mentioned for this, such as there being no ventilation out from the rooms above and others of a like class, but one reason (and, I may add, one very little suspected by a great many so-called furnacemen) is to be found in the contracted and the altogether too small space allowed for the passage of air between the outside bottom casing ring at the base and the ash-pit of the furnace itself. I have seen cases where furnaces had ample heating surface to heat enough air for 500 to 600 sq.″ of outlet, but all the space it was possible to figure out which these botchy and poorly designed furnace bases had for air passage was perhaps from 275 to 325 sq″. Practice such as these conditions denote needs no further comment.

Another error that some furnace designers and furnace setters commit is that the air space allowed for the passage of the heated air between the casings or the brick walls of a setting, as the case may be, is in most instances altogether too large and out of proportion to the heating surface of the furnace. This space need not be any larger than the outlets are for any furnace providing that they are of the correct area proportionate to the heating capacity of the furnace. By having this space around a furnace too large and the number of outlets in most cases more than the furnace is able to properly take care of, the flow of air is not as rapid and the air is not heated to the degree demanded for the proper heating of the rooms above.

The method I advise by which to obtain the proper amount of space for the purpose set forth in the foregoing in brick settings of furnaces is by

the placing of trench plates in and around the brick work at regular intervals, regulating the distance that they are to be away from the furnace according to the area desired for each case. In sheet-iron cased or mounted furnaces the only thing that the furnaceman can do to remedy a faulty or disproportionate design in the make-up of the castings of a furnace itself so that it will will tend to work as it should, is by placing plates directly over that part where the cold air enters the casing from the cold air duct, if the same is fastened to the casing so that the air enters through the casing at the back or at one of the sides above the base ring of the furnace. Cold air boxes, connections, chutes and ducts are made of different kinds of material. Ducts are generally used for the purpose, made of brick usually for underground conduits and in some cases also for the vertical shafts. The cold air chutes and boxes are mostly made of tongued and grooved or matched boards. These cold air boxes are generally used for those styles which are built entirely above ground, but in some cases where a cheap job was done I have seen two-inch thick planks used for the underground duct. Galvanized iron connections are used to connect the furnace with the end of a wooden chute or cold air box. These connecting parts made of galvanized iron are usually made from 18 "to 24" long, as it is not safe to connect a wooden box to the casing of a furnace any nearer than the distance given in the foregoing. A good plan is to provide the connection with an upward turn extending somewhat above the top of the horizontal top part of a connection; this entirely prevents the possibility of any heat rays from a furnace fire-pot setting fire to the wooden air box which may occur if the wood is exposed.

When building the air supply boxes of wood nothing but well seasoned boards which are free from knots should be used. The best kind of boards for this purpose are flooring boards, dressed, tongued and grooved. Always use the planed side inside when building a cold air duct, so that the air has a smooth even surface to flow over and against during its passage from the outside to the furnace. When building the air ducts of brick it should be seen to that there is no possibility of any foul water collecting in the duct or by any chance any sewer gas finding its way to the air duct. To prevent this the duct must be well cemented. The way to do this will be given in the details for the construction of these ducts. If there should be any danger, as there sometimes is in cases where there is no sewerage or a sufficient fall for drainage that water may slip in the cold air duct, a good plan is to dig a well on one side deeper or lower down than the air duct, in which the surface water can collect and be easily removed by pumping once in a while. Never under any circumstances attempt to drain a cold air duct or air pit into a sewer, as, even if this

method would drain the pit dry, there would always be the danger of sewer gas escaping into the furnace pit. Another point to be seen to is that if the cold air duct has a twisted course, or in other words, a number of bends and corners to turn, always be careful not to reduce or restrict the area to a less section than is required for the proper working of the duct so that it supplies a sufficient amount of air for the furnace. The simplest methods to supply a furnace with the requisite amount of air is to set it up on legs. By this method the air in a room or cellar is used as a supply and the furnaces must have a sufficient supply of air to heat well. If it is not desired that the furnace be set up on legs the next cheapest plan is to take the air in through the sides of a casing as shown by Fig. 210 at A. In fitting up this style of inlet usually three cast-iron air panels are bolted to the casings. A cheaper way is to use galvanized wire netting to fasten over the cold air opening for this purpose. The foregoing method has the disadvantage that if it is used on a casing of a furnace set up in a cellar the fresh air must be drawn to the openings in the casing from some open window or other opening provided for the purpose. The air passing from this opening to the openings in the furnace casing would naturally tend to cool off the hot air pipes leading from the furnace. This point and also the practice of drawing the entire air-supply from the cellar is one that does not recommend the method very much, but a good many instances are to be met where it is used. This method is also used to a great extent to supply the bottom feed for the circulation of air through room heaters. Thi

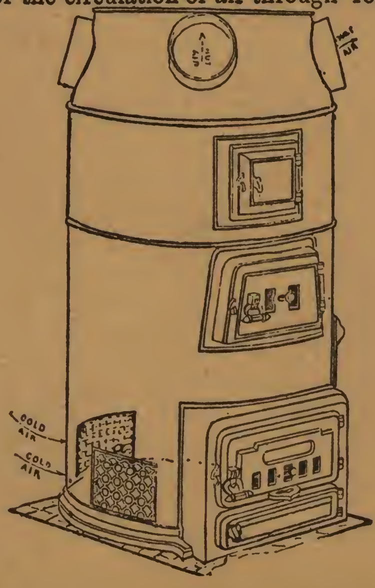


Fig 210.

system of causing the air to circulate through the heater is particularly to be recommended where such heaters are used to heat up large stores, shops, etc., especially when a steady supply of cold air is flowing to the heater, caused by the opening of the front stove door. For school-rooms, halls or churches this style of air supply is not permissible but air should be brought to the furnace or heated from outside. How this is usually arranged is shown by Fig. 211. In this figure is shown how the cold fresh air can be taken in through the duct A open to the outside of the building. B shows a cut-off which can be opened or closed at pleasure. At C is also shown a register let into the floor and connected with the cold air duct underneath the floor. When this register is open and the shut-off B is closed the heater draws its supply of air from the same room in which the heater is located. This arrangement has the advantage that if it is desirable to keep the room heated without ventilation, as in the case of a schoolroom during the night, this can be done by this system at a greatly re-

Fig 211.

duced cost from that system which demands that all the air heated must be drawn from outside when the ventilation registers and ducts are to be kept constantly in operation removing the contaminated air from the room.

This is imperatively necessary when the school, church or hall is occupied by a number of adults or children, but is not absolutely required

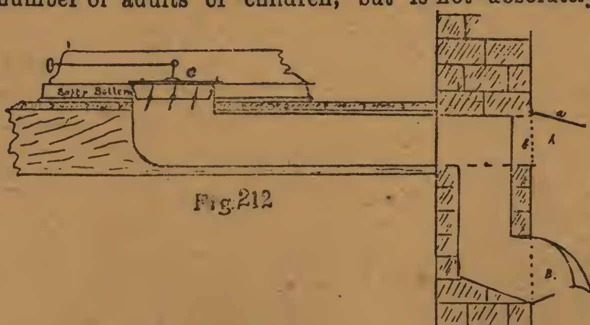


Fig.212

when the space is not used as indicated in the foregoing. Fig. 212 shows a sectional view of the opening as made for the air to flow in through the duct to the heater. A shows a straight outlet covered by a shield A to prevent the rain, snow, etc., from driving into the opening. The mouth B is to be covered by a $\frac{3}{8}''$ mesh galvanized wire screw. B shows another style of opening. The object of making it as this figure shows is to avoid having the wind blowing directly into the mouth of the duct. This method of placing the mouth is a more expensive way than shown for A but it serves the purpose well in so far as no direct drive of wind can occur through this tyle opening. This Fig. 212 does not show a register placed in the floor but instead a regulating register at C. The register box is shown to extend up through the safety bottom into this. The register is bolted and a rod fastened to the register-wheel as shown, which allows the easy regulating of the air supply to the heater at will. Fig. 213 shows a cold air box connection to the side of a casing. The first part of the box is to be made of galvanized iron to be equal in length to the height of furnace casing, the remainder is to be of wood and the cold air to be taken from the outside of building. With brick-set furnaces a connection of this kind is made to the air chamber through the bottom of the side of brick wall. For this kind of a setting it is only necessary to make the connection one joint high of galvanized iron to be perfectly safe and secure from any danger of the air box being set on fire by heat rays from the furnace.

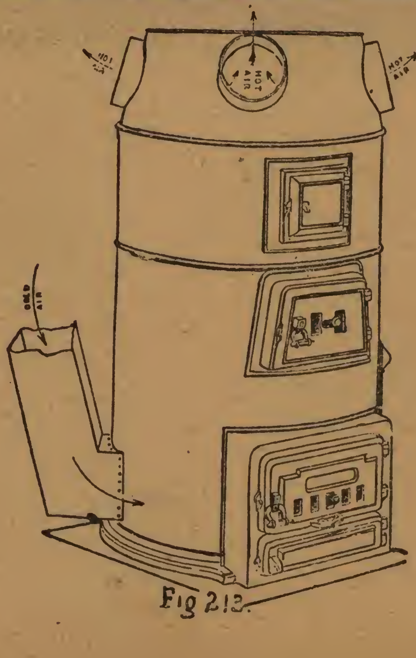


Fig 213.

Fig. 106 in Chapter XVI shows a straight-out connection for a cold air box which may run along the floor of a basement or may be joined to an inclined chute connecting it to the outside of a building. This style of connection and the style shown by Fig. 213 are made up in quantities by some firms. The size being determined that the connection is to be for a given size furnace the pattern of a suitable air duct connection is made, and from this any number of connections are cut and made up ready for use when required. It is almost needless to point out that this system of making the cold air connections all alike as to area often causes the opening to be too small. This is due to the furnace man crowding more work on the furnace than it is able to do, and one of the consequences is that the cold air inlet is too small to supply the outlets, necessitating a fiercer and stronger fire to be kept up in the furnace in order to supply this deficiency by a stronger and faster flow of air through the duct (which can

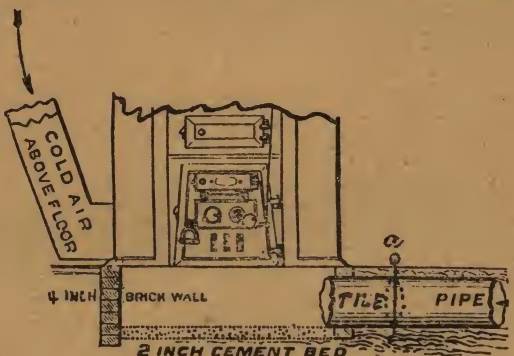


Fig 214.

only be caused by a hotter fire), and this in some cases overheats the apparatus. The best plan to follow for work of this kind is to make the duct just right; how this is done has been fully shown and explained before. By Fig. 107 in a former article is shown still another style connection. This style is what may be termed a half-and-half connection because one-half of the connection is fastened to the furnace casing proper, while the lower half connects with an air-pit underneath the furnace. I have used connections for furnaces similar to this figure where it was not advisable to dig a pit too deep for the cold air, this in some cases being due to the surface water sapping through the brick-work into the furnace air-pit. There are certain districts where some such plan must be used if a reasonably cheap job is to be done, and at the same time to be tight and dry. Fig. 214 shows a cold air duct connection as described and shown by Fig. 213 on one side of a furnace, and on the other side is shown a cold

air duct conduit made of a large-sized tile, supplying air to a pit under the furnace. At a is shown a damper to shut off the air from this source. These two ducts as shown can be connected to the same furnace, one taking the air supply from the hall, while the other has its source of supply from outside. The two pipes are not to be used at the same time. It is not at all likely that they will work satisfactorily if used together. They are not designed with this end in view, as the arrangement of Fig. 214 shows.

By Fig. 215 is shown a cold air duct, taking the supply of air from outside at a, shown in the drawing. To this duct is connected a cold-air return pipe from a hall or from a room above. It will be seen that a dividing plate or tongue is inserted in the main duct so that if it is desired to use both the outside and the air from the room above to supply the fur-

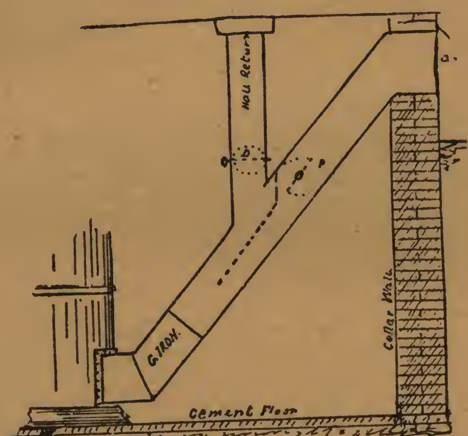


Fig. 215.

nace with cold air, this can be done. Care must be taken to regulate the dampers of the two supply pipes, so that the combined area of the flow allowed will be no greater than the demand for air the furnace requires, while both sources of supply are used together. D and P are the two dampers to be used whenever it is desired to shut off one or the other of the two supply pipes.

Fig. 216 shows another style and arrangement of pipes differing from the style shown by 215 in its general shape. Instead of having the outside supply pipe in one straight duct from the window to the furnace and the hall pipe connected to it, the order in this Fig. 216 is reversed by making the pipe leading from the rooms above the main pipe, and the supply pipe for the air from the outside, as the auxiliary or branch to the main pipe.

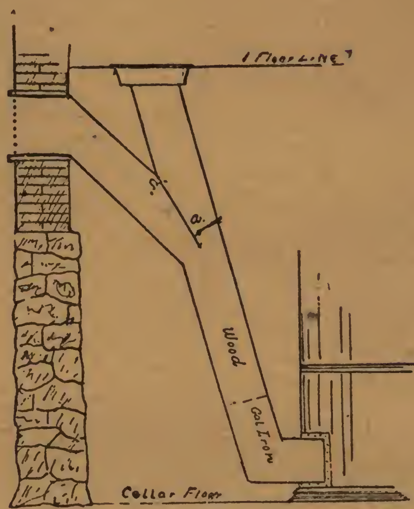


Fig 216.

This style or combination is particularly adapted for furnaces used to heat halls, churches and lecture rooms, where it is desired to heat the rooms for

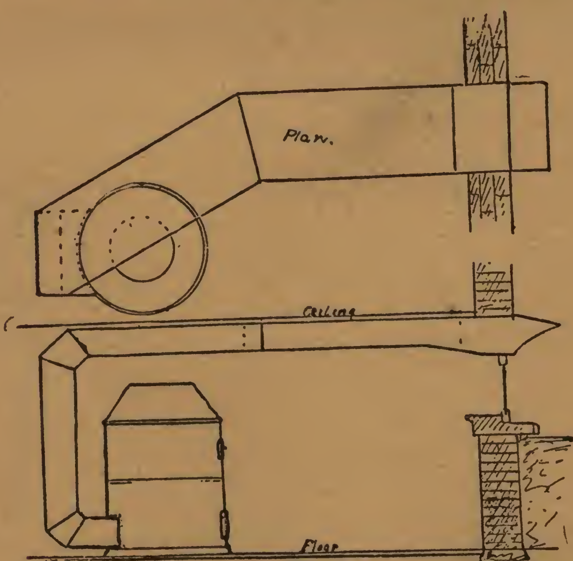


Fig. 217.

a considerable length of time before they are to be occupied by any gathering of persons, by using the air from the room itself. The straight chute as shown by Fig. 216 offers an easy, smooth course for the air to travel, and for that reason is the best arranged duct for the purpose. Ducts used for the purpose set forth must have a sectional area equal to the outlets from the furnace, this because when the air finally becomes warmed up the circulation will not be as rapid as in the first start, when the fire in the furnace caused it to be heated and set the air moving through the duct and out through the furnace to the space above and eventually down through the duct again. These conditions are to be met by providing a large area for the supply pipe which is used to conduct this air to the fur nace. The outside air supply duct does not need to be made any longer than the normal demands require. When the time arrives, or shortly before, the rooms above are to be occupied, the supply of air from the inside return pipe is to be entirely shut off and the air is only to be taken from outside. This supply of air in conjunction with the ventilating ducts of the rooms above for exhaust gives the required circulation of air demanded for the ample supply of fresh and warmed air, both to heat the space as well as for the respiration for the persons assembled therein. In this case the ducts are shown to be built of wood. The valve or shut-off is hinged at the top and regulated by a cord or chain as shown at a. The duct is connected to the furnace by a galvanized sheet iron connection as described and shown by Fig. 213.

The two styles shown by Figs. 215 and 216 could also be arranged so that they could connect with a pit under the furnace instead of being connected to the furnace casings above the base ring as shown. Fig. 217 shows a plan and a side elevation of a cold air duct, made entirely of galvanized sheet iron. This drawing shows an example of the practical application of some of the parts of a cold air duct described before, and also how to arrange them when, as in a case as presented by this figure, a furnace is set in the basement of a house in a block, the room being used for a billiard room or a dining-room, as the case may be. The object is to get the air into the furnace with as little loss of space as possible. Fig. 217 shows how a job of this kind was done successfully. The example as shown is only one instance of the many perplexing problems that the average furnace-man is called on to provide for in the usual run of furnace work. A good exercise for the student would be to lay out this cold air duct in the flat and plan out the best method by which the air could be checked from blowing down the duct; this to be accomplished either by a hinged valve or by a sliding shut-off. One of the handiest tools for turning up edges on work of this class is given in Fig. 218. A full size

drawing is shown. This tool makes it unnecessary to take large sheets and either turn the required edges up by a machine or by the use of a hatchet, stake and mallett, which is often rather unhandy, but the edges can be bent up nicely with this tool. The figure gives an end view of the tool. The length flatways can be made either from four to eight inches long as desired. The tool is made out of two pieces of No. 18 gauge and one, the center piece, of No. 14 gauge iron. These riveted together as shown constitute the tool. I have found it very handy in this class of work. Having described some of the styles of ducts used entirely above ground I will next give a description of the manner of arranging the cold air pits for the various styles of settings of furnaces, portable and brick-set, and also the ducts connecting them with the air supply from the outside.

Fig. 219 shows a style of arrangement of the air pit for a portable furnace. The outside circular wall is built of brick up to the height desired its top course being either level or somewhat below or above the floor line of the room that the furnace is placed in. The central pier is 9' square and is built up to the level of the wall so that the bottom of the furnace rests on it; while the outside base ring is set on the circular walls. The central pier is built up that the current of air entering the pit from the duct flows up to the pier and is divided by it into two equal parts so that each side of the furnace has an equal supply. As shown in the figure, the duct is built out a short distance from the pit, allowing at least two feet from a to b before the edge of the wooden connecting air box is joined to the brick duct. The bottom of the duct and pit can be either paved with brick, cemented only, or, as in some cases, the bottom has nothing done to it at all in the way of covering it up, the pit having what is commonly called an

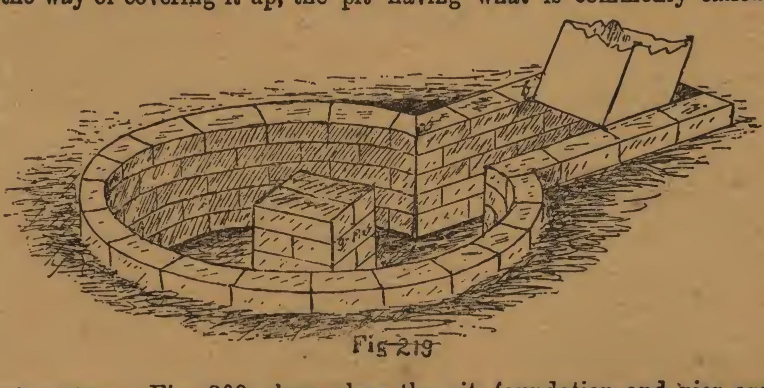


Fig 219

earth bottom. Fig. 220 shows how the pit, foundation and pier are arranged for a brick-set furnace having the same style pier as described for Fig. 219. This figure shows the air duct connected with the setting from

one of the sides. By using this style of pier it does not matter so much from which direction the air is introduced into the air pit because the air has a good chance to flow all around the center pier. But if a center support, as in the style shown by A of Fig. 221 is used, the air supply will

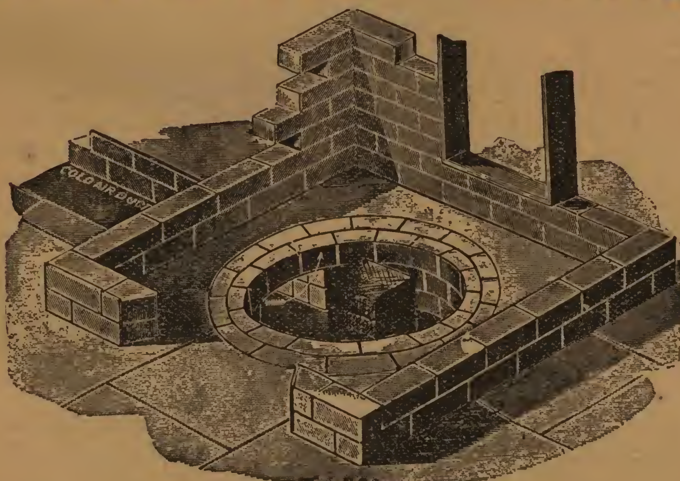


Fig.220.

work best if it enters the pit or setting at the back, as B shows, although many furnace-setters take the air into the pit as shown by the duct C, or from one of the sides. The preferable plan is to take the air in from the back if it can be done. This is impossible to do in some cases. If the

Fig 221

conditions are such that it cannot be done, one of the sides may be used, but I would advise to use the style of pier shown in Fig. 221.

Figs. 222 and 223 show a plan and elevation of a branch leading to the main duct. The conditions shown by these two figures are that one of the ducts conveys the return air from the rooms above to the main duct, which conveys the supply from the outside, but both these ducts are built of brick and are underground or below the level of the cellar or basement floor. Fig. 222 shows by plan view how the two ducts are built and unite into one channel to the furnace. Figs. 222 and 223 show how the shut-off drop doors are operated. In Fig. 223 the main duct is shown shut off while the auxiliary duct is open. Ducts of this kind are built where the down shoot of either the main duct or the return duct is some distance

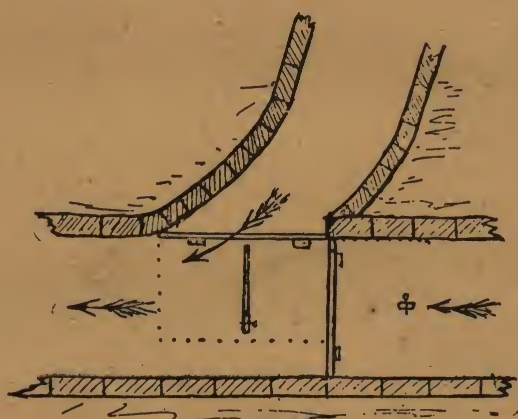


Fig 222

away from the other and it is not desired that the connecting duct should be above ground; as, for instance, if the duct would have to be carried across the entire distance or length of a lecture room, etc., if the same were situated under the room from which the return pipe is taken.

The method of closing and shutting off these ducts from each other as shown in Figs. 222 and 223 is as cheap and as simple a way as could be

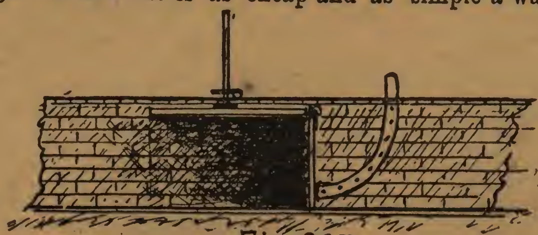


Fig. 223

devised, and, I may add, in addition to this it is a very good way for the purpose. Fig. 224 shows the entire side elevation of a cold air box, the duct underneath the level of the cellar floor, and an air pit for a portable furnace all complete. A is the box made of pine boards tongued and grooved, planed on both sides. This box extends from the mouth, at S, down to the top of the brick duct, B. A door is shown at F. At G is shown the damper or shut-off, worked by means of a crank with a rack.

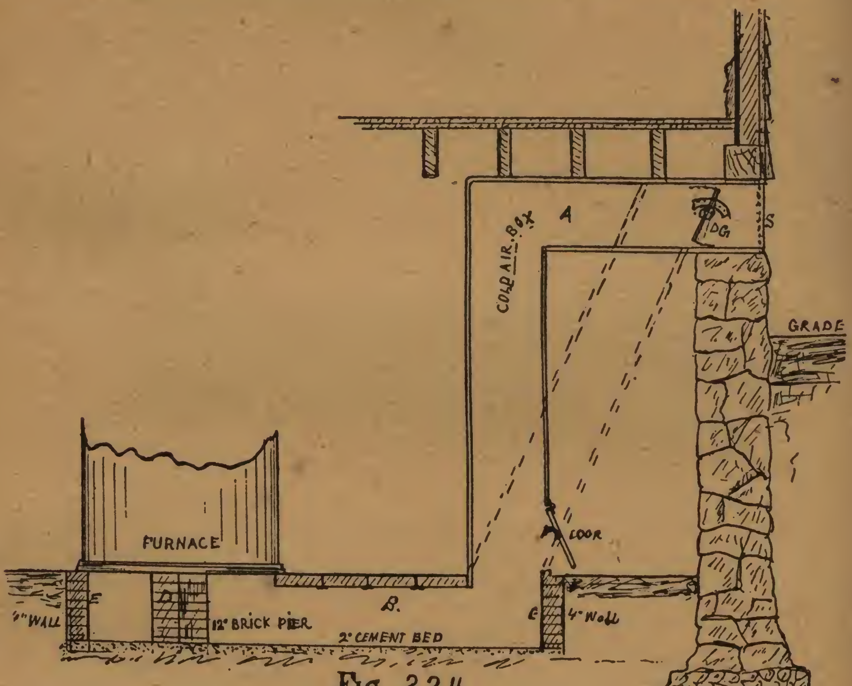


Fig 224

The mouth of the duct is provided with a galvanized iron screen of one-half inch mesh. As shown in Fig. 224 the bottom is a two-inch thick cement bed. E E are the upright walls at each extreme end of the brick-work shown. D is the central pier for the furnace to be set on. Above B is shown the brick covering of the duct. These bricks are supported by tee iron bars laid crosswise over the duct. A somewhat different style for the cold air box is shown by the dotted lines. This latter course would save some material, but would require in the construction some nice fitting to make it air-tight.

Then it has this much to show in its favor that it does not take up as much room as the style shown by the solid line drawing. In Fig. 225

is shown a favorite style of arranging the cold air box in connection with a brick duct. The first part to attend to is to board or ceil up the top of the box as shown by A. The sides are next put up and the front up to D. From D to C is to be left open, somewhat less in height than the width of

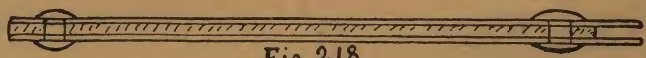


Fig. 218.

the box is out from the cellar wall—usually this is about three-fourths of this distance; then, above this, the sash that is taken out of the frame S is put in at this part of the box as shown at B. This last disposition of the sash allows the light to pass through without in the least interfering with the practical working of the air box. The opening left in the front from D to C is to be closed by a drop door hinged at C and used as a check against the flow of air from the outside, using the cellar air instead. The handle D is hinged to the drop door at its other end, and is to be provided with projections so that the door E can be opened to any degree as may be desired, or for which projections are provided on the handle. A wire screen is to be nailed or fastened over the mouth of the box at S.

The style of cold air box of which a general description has just been

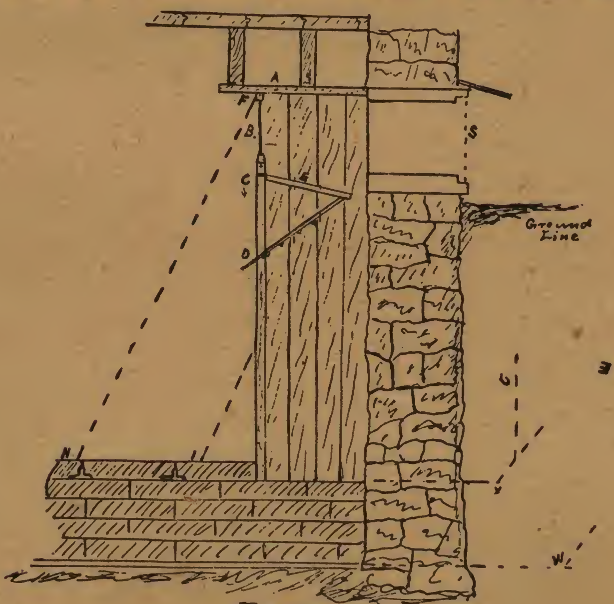


Fig 225

given will do very well for the purpose anywhere throughout the country where the winter weather is not too severe. I would not advise to put up a box of this kind using the cellar wall for one side of the box, or, in other words, building up the two ends and the front only, joining the two ends close up to the wall, thereby saving the building up of the fourth wall of the box, in parts of the country where the weather is very severe, say down

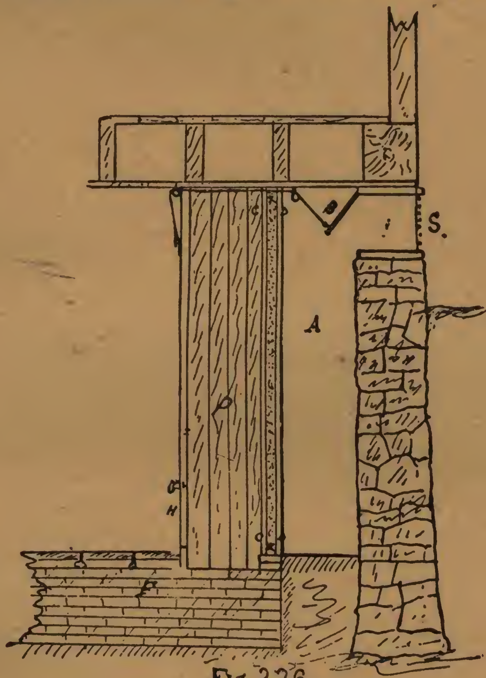


Fig. 226.

to 40° below zero at times, and where the soil is of a clayey nature. If a box as described is put up in such a locality against a cellar wall it is very likely to heave, or, in other words, the wall is likely to be affected by the intense frost which the extra exposure caused by the cold air box would subject it to. A far better plan would be to build the air box as the dotted lines from E to H and I show. A box built that way would reduce the danger to the wall to a minimum, and is a far safer plan to follow if the circumstances are as indicated in the foregoing. Another style of duct is sometimes built where it is not possible to run the duct out through a window. This is indicated by the dotted lines showing a continuation of the underground air duct and through the cellar stone wall, then either running straight upward, as the lines T U show, or else running in the lateral direction, as the lines X W indicate, leading to whatever place the mouth

or inlet is to be placed at for the cold air duct. Whenever a duct has its outlet on the outside of a building it is a good practice to run it up four or five feet above the level of the surrounding ground. Fig. 226 shows an air box and a device to filter the air entering through the mouth at S. The space shown by A is the settling chamber; B is the damper regulated by the rope as shown. At S is fastened the outside screens of galvanized wire of about $\frac{3}{4}''$ mesh. This device for separating the fine particles of dust, etc., from the air may be described as follows: C, C and D, D of Fig. 226 are two frames as long as the box is high from C to C and extending the entire width of the cold air box. Both of these frames have a galvanized wire netting stretched across their entire ends. The netting is to be of $\frac{1}{4}$-mesh; the two frames C, C and D, D are to be fastened together after the space, as shown by X, X, has been filled with loose cotton batting or two or three layers of coarse cotton cloth, or, if preferred, layers of ladies' veiling. This arrangement is to be made so that the filtering material when it becomes clogged up and dirty can be taken out and from time to time cleaned or removed to make place for a fresh snpply. The air from the outside is received at one side of the filter and after passing through it goes down the air box D to the air duct F, through this and up to the furnace, and thence to the rooms that are to be heated by it. The arrangements for filtering and purifying the air as described in the above are particularly of value where the supply of air is drawn from an opening facing some dusty thoroughfare, and ought to be made use of in all cases for churches and public buildings to provide the occupants with as pure a quality of air as it is possible to obtain with the aid of such a device. The other air impurities in crowded rooms being the carbonic acid and emanations from the occupants cannot be prevented, but can be rendered harmless by the aid of a proper ventilation system of the apartments of the building so that the only function of the air supply box would be to supply the heater with air as free from foreign substances as possible. This can only be done satisfactorily by filtering, cleaning or separating all such foreign matter by means of some such device as is shown by Fig. 226. Thus, altogether, the best possible conditions are offered for pure air to the occupants of the apartments supplied by the described air filters, ducts, etc. Some firms in erecting heating plants for large buildings follow the system of first conducting the cold air supply to one large storage or pressure equalizing room, and from this to the furnace, claiming that by doing so they secure a steady, even supply of air to the heating apartment irrespective of how violent or from which direction the wind blows. This system may be all right enough for large buildings, but the plan is not used to any great extent for ordinary buildings, being somewhat expensive, and in most cases the lack of

sufficient room would entirely prohibit the employment of such a system for the regulating and equalizing of the air supply and consequently is only used in isolated cases.

The first step to be taken when an underground cold air duct is to be built is to lay out the plan and mark off the exact location of the lines that are to be followed by the laborers when excavating and digging the trench wherein the cold air duct is to be built. Do the same for the cold air pit under the furnace. The size of the pit depends upon the base ring. The depth and width of the cold air duct trench depend upon what the area is required to supply the furnace with air according to the data and rules given in the fore part of this chapter. To figure the cost, whatever the measurements may be, for any certain job of excavating for an air duct and air pit under a furnace, add up the amount into cubic feet or cubic yards. The following data shows the amount of work one man is able to do, and what is considered a day's work. When the ground is of a clayey character the average day's work is from $1\frac{3}{4}$ to 2 cubic yards dug up and pitched five feet high or on one side. If the soil is gravel and of a sandy nature 3 to $4\frac{1}{2}$ cubic yards is considered a good day's work, if all the condititions are favorable. If the digging has to be done in a restricted and cramped place a less amount of work can only be expected; circumstances as they exist at each job must be taken into account when the calculations are made as to the time it will take, etc.

One cubic yard of earth or gravel after being dug up and turned over will occupy about one and one-half cubic yards of space. Clay and earth weigh about one ton for every 25 to 28 cubic feet; 21 cubic feet of sand weigh one ton and 23 cubic feet of gravel weigh one ton.

After the trench and the pit are dug and ready for the brick-work the first point to determine in the calculations is what kind of a job is to be done for this particular duct. This is governed mainly by the nature of the ground where the duct and pit are to be built. If the ground is of a sandy and gravelly nature and the drainage is good a comparatively cheap structure will answer the purpose. Such a one is shown in section by Fig. 227, being the style usually built in cellars where the floor is not cemented. This duct consists of two vertical walls built up against the sides of the trench and also of the air pit of a furnace. A and B show the two upright walls. The floor or bottom is merely plastered over with a layer of mortar. The sides of the upright walls are to be treated in the same way. For covering, heavy cross pieces are placed at intervals of several feet of the entire length of the duct walls, and on these the board coverings are nailed as shown in the drawings. This duct is the cheapest kind that can be made to answer the purpose. The plastering with mortar of the side walls and

bottom could be omitted, thereby saving that expense, but I do not regard this as good practice.

Fig. 228 shows by section how a first-class job of this kind is built. If the ground around the duct and furnace pit is of a kind from which there is any danger of water filtering through the mortar joints of the

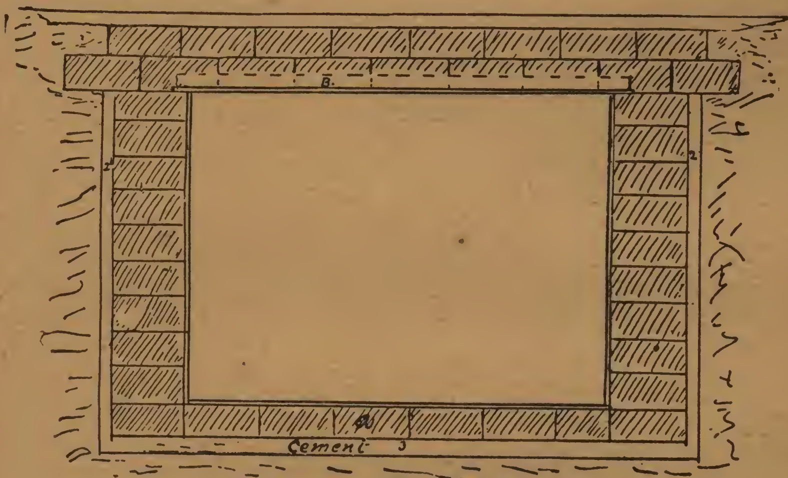


Fig. 228.

brick work, the duct must be built after the following directions: First, bed a solid floor of brick, laid flat in cement, as shown by A of Fig. 228. Then lay the courses of brick of the upright walls with cement for the joints, and also against a bed of cement between the bricks and the outside earth, as shown by 2, 2, of Fig. 228. For the support of the brick roof or top of the air duct cast-iron tee covering bars are to be placed the length of a brick apart from each other and the first course of top bricks is to be laid cemented together side to side. A second course of brick is to be laid on top of these and above them the inch cement floor is laid. The entire inside of the duct is to be plastered with a layer of cement one-half inch thick before the top is put on. It would be well to flush the bottom of this duct with cement and have it well grounded. No matter how wet the outside soil may be the interior of the duct and furnace air pit will always be clean and dry if the foregoing method is followed in the construction of an air duct demanding absolute freedom from soil water. The following is the quantity of brick necessary to lay one square foot of bottom if the bricks are laid the flat way, as shown by Fig. 229. If the brick are 8" long and 4" wide it will take $4\frac{1}{2}$ for a square foot of floor. For the side walls, if the brick are laid with $\frac{1}{2}''$ mortar or cement joints, the brick being $2\frac{1}{2}''$

thick and 8″ long, 4″ wide, for each square foot of superficial surface of a 4″ wall, it takes 6 bricks. For the same style wall but built of bricks each 2″ thick, 8″ long and 4″ wide it requires $7\frac{1}{2}$ bricks per square foot for 4″ walls. Figs. 230 and 231 show how the surfaces are measured for both styles of bricks. Fig. 230 shows a square foot of wall built of $2\frac{1}{2}$″ thick bricks, while Fig. 231 shows one square foot of 4″ wall built of brick each 2″ thick with one $\frac{1}{2}$″ mortar or cement joints. Both figures are drawn to the scale of 2′ to the foot. The cost of covering bars used to support the

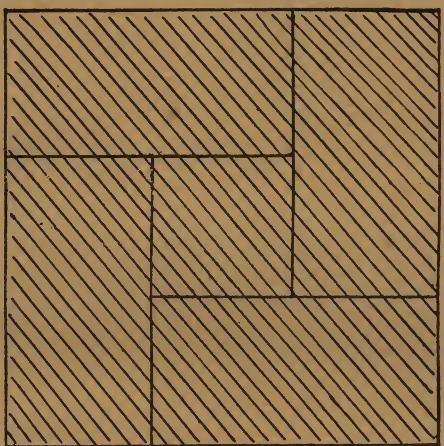


Fig 229.

top of the air duct are figured as so much per pound. This varies according to the market price for rough cast-iron and must be figured accordingly. The proportion of sand to be used for every two thousand brick is one cubic yard of clear sharp sand, and for a good quality of mortar three bushels of fresh lime should be used. The proportions to mix a good hard-setting cement, so that it will resist moisture and leakage best, is one barrel of the best Portland cement to two barrels of clear sand. To figure up the lumber it requires to build a cold air box, take the number of square feet needed for every superficial foot of surface contained in the box. Then if the wood work is made of matched boards, that is, tongued and grooved, an allowance must be made of $1\frac{1}{2}$″ by 12″ for each square foot, or 18 inches must be added to every square foot of surface the cold air duct has. The reason for this is that the tongue and groove take $\frac{3}{4}$″ from each board, leaving a board 6″ wide but $5\frac{1}{4}$″ wide for actual use. When ordering the boards the full 6″ wide are charged al-

though only $5\frac{1}{4}''$ can be counted as actual surface for use, consequently it is best to order 3-24ths, or, to be safe to cover the waste for cutting, etc., 1-6th more boards than the actual surface of the cold air duct measures.

Fig 230.

The other incidental items, such as nails, hinges, pulleys, time, labor, wire screens, etc., are all to be taken into account when summing up the cost, or making out a list of the necessary materials to build a cold air duct for a furnace. Another point that I would advise the student to study is how to do his own brick and carpenter work that may be required for the setting of a furnace and the building of a cold air duct for the same. I have seen furnacemen who have become quite expert at these branches of the work and who, in time, owing to the very peculiar and superior manner in which furnace setting and brick and carpenter work connected therewith must be done, could give good bricklayers many "pointers" in this class of brick work.

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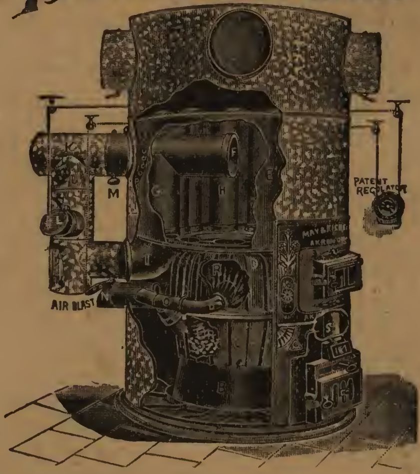

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INDEX.

A

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

S

T

U

V

W

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